How Allocation of Cognitive Resources May Alter Handicap

Influence possible des ressources cognitives sur le handicap

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Abstract

Hard-of-hearing people often say they do not fail to understand what is said; rather, they find it tiring to listen. To explore how difficulty in understanding is attributed to problem sources, situations were described to normal-hearing and hard-of-hearing subjects who were asked to report as many reasons as they could for why a person in the situation might have trouble understanding what was said. Few listed hearing loss as a possible reason for misunderstanding. Nevertheless, many reasons did relate to the physical or psychological state (for example, fatigue or anxiety) or cognitive abilities (for example, lack of knowledge or divided attention) of the listener. Other reasons related to the communication partner or the communication environment. Overall, people seem to be more aware of the 'upstream' by-products of hearing loss than of the strictly auditory aspects of their impairment.

Abrégé

Les personnes malentendantes disent souvent que, pour eux, le problème n'est pas le fait qu'ils ne comprennent pas ce qui est dit, mais plutôt la fatigue ou l'effort requis par l'écoute. Pour essayer de comprendre à quelles causes la difficulté de compréhension est attribuée, des situations typiques ont été décrites à des entendants normaux et à des malentendants. On leur a ensuite demandé d'imaginer toutes les raisons possibles pour lesquelles un individu dans la situation en question pourrait avoir des difficultés à comprendre ce qui a été dit. Très peu mentionnent la diminution de leurs capacités auditives comme cause possible. Plusieurs raisons données, cependant, font allusion à l'état physique ou psychologique de l'auditeur (fatigue, anxiété) ou à ses capacités cognitives (manque de connaissances, distraction). L'interlocuteur et l'environnement sont deux autres raisons avancées. En conclusion, il semble que les gens sont conscients davantage des conséquences et des obstacles généraux d'une perte d'ouïe que des aspects plus strictement auditifs de leur infirmité.

A widespread complaint of hearing-impaired people, even those who may have no disability when listening in ideal conditions, is that they have difficulty understanding spoken language—and are therefore disabled—in many of the typical situations encountered in everyday life that are noisy or reverberant (for a review see CHABA, 1988). Murray Hodgson (this issue) provides us with a tutorial on how the acoustical environment may affect listeners. To reiterate Hodgson's point: the world is a noisy place and the acoustical environment modulates the performance of listeners. But how noisy is the world? Some examples of the typical speech and noise levels found in everyday situations (see Table 1) are provided in the Report of the Committee on Bioacoustics and Biomechanics (CHABA) Working Group on Speech Understanding in Aging (Pearsons, Bennett, & Fidell, 1977, cited in CHABA, 1988). The noise level in a quiet suburban living room, for example, is about 45 dB A.

Table 1. Examples of Speech and Noise Levels in Typical Everyday Environments

Situation	Ambient noise level	Typical speech-to-noise ratio
Suburban home	45 dB A	14 dB S:N
Urban home	55 dB A	9 dB S:N
Suburban backyard	47 dB A	8 dB S:N
Urban backyard	65 dB A	5 dB S:N
Department store	54 dB A	7 dB S:N
Aircraft or subway	77 dB A	-2 dB S:N

Note. Examples based on Pearsons et al., 1977, cited in CHABA, 1988.

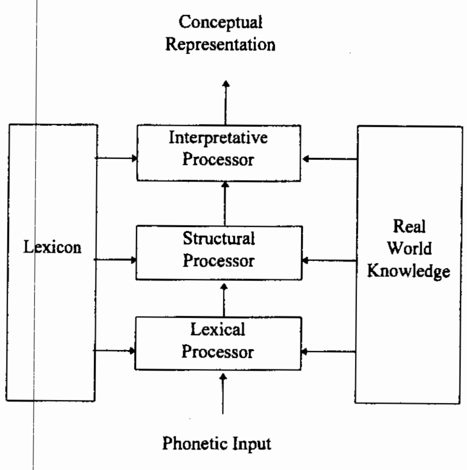
Of course, talkers adjust the level of their voices somewhat when they are in noise, but not enough to maintain an equivalent signal-to-noise ratio in all conditions. As the signal-to-noise ratio drops, speech intelligibility declines rapidly for normal-hearing young listeners. In a living room, at about +12 dB S:N, we would expect such a listener to correctly and effortlessly identify 100% of the words that were spoken. In an aircraft, at around -2 dB S:N, we would expect the same listener to struggle to hear, and the accuracy of word identification to drop to 50% or less. Notice that, in everyday life, listening changes from being easy to almost impossible over a range of as little as 10 or 15 dB S:N. When we listen to signals near threshold, at the most adverse end of the range of everyday signal-to-noise conditions, a drop of only 1 dB S:N could result in as much as a 20% drop in word identification (Dusquesnoy, 1983). In such conditions, even non-impaired listeners are effectively disabled. Needless to say, this situation changes for the worse if we consider the performance of hearing-impaired listeners.

Information Processing by Hard-of-Hearing Individuals

An initial step in moving from a focus on impairment to a focus on disability is to consider not just what information is perceived, but whether or not listeners can manipulate or use the information that they hear in order to arrive at a coherent interpretation or understanding of its meaning. As depicted in an adaptation of Cairn's (1984) model of language comprehension (Figure 1), a listener arrives at an interpretation of what is heard by submitting ongoing sound (phonetic) input to linguistic processes, and integrating this analysis with information available in working memory that has been extracted from recently heard portions of the message and with semantic and world knowledge retrieved from long-term memory. Simply put, hearing may not be *sufficient* for comprehension. Hearing—at least perfect hearing—may not even be *necessary* for comprehension. Some balance of bottom-up and top-down processing, however, does seem to be required for listeners to achieve comprehension. I became interested in studying how bottom-up processing fails in unfavourable listening conditions, how top-down processing might compensate for failed perception, and how such trade-offs might affect how listeners comprehend spoken language. More generally, I became interested in how cognitive performance might modulate handicap resulting from hearing loss.

Figure 1.

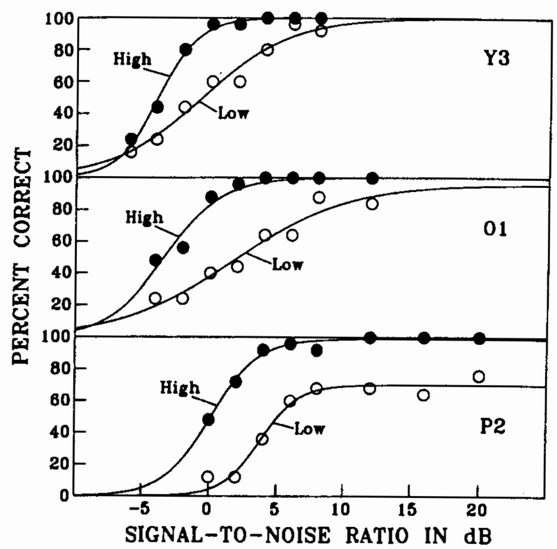
Adaptation of Cairn's (1984) model of language processing



In a preliminary experiment (Pichora-Fuller, Schneider, & Daneman, 1995), young and old subjects with good hearing and old hearing-impaired subjects listened to the sentences of the Speech Perception in Noise (SPIN) test (Bilger, Nuetzel, Rabinowitz, & Rzeczkowski, 1984; Kalikow, Stevens, & Elliott, 1977). The SPIN materials consist of eight lists of 50 sentences; in each list, half the sentences provide supportive context ("The watch dog gave a warning growl.") and the other half do not ("John spoke about the growl."). The sentences are recorded with speech on one channel and competing babble on the other channel. The lists are known to be equivalent when the materials are presented at +8 dB S:N. The usual task of the listener is to repeat the sentence-final word. Consider the results for one typical subject in each group: a young listener, an old listener with good hearing, and an old listener with hearing loss (Figure 2). When the level of the signal is high

Figure 2.

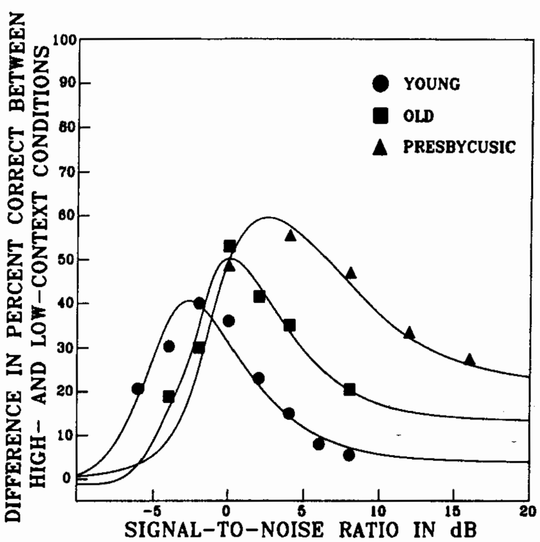
The percentage of correctly identified words heard in low-context and high-context sentences as a function of signal-to-noise ratio for three examples: a young subject (Y3), an elderly subject with good hearing (O1), and a presbycusic subject (P2)



compared to the noise, all subjects perform well, with or without context, although, not surprisingly, the hard-of-hearing subject never reaches 100% correct identification for words presented in low-context sentences. When the level of the signal is about 5 dB lower than the level of the noise, all subjects find the task extremely difficult, whether or not the sentence provides context. The signal-to-noise conditions of interest to me are those in the intermediate range, where listeners maintain good performance if there is supportive context but have much more trouble without it. Although they correctly identify many words under these conditions, it seems that they must rely on context to do so well. In these conditions listening becomes effortful. The difference between the number of words that are correctly identified in high-context sentences and the number correctly identified in low-context sentences is an index of how much a listener benefits from context; presumably, this indicates the payoff of exerting extra concentration or mental effort during listening. Figure 3 illustrates how a group of young subjects, a group of elderly subjects with good hearing, and a group of presbycusic subjects benefit from context as a function of signal-to-noise condition. Notice that the presbycusic listeners always rely more heavily on context, even in the more favourable signal-to-noise conditions.

Figure 3.

The difference in percent correct between high-context and low-context conditions as a function of signal-to-noise ratio for three groups: young subjects, elderly subjects with good hearing, and presbycusics (n = 8 for each group)



Having established the signal-to-noise conditions in which listening is effortful, we were able to go on to study whether or not the need to divert mental resources to listening would undermine comprehension (Pichora-Fuller, Schneider, & Daneman, 1995). Why would cognitive resources be a potentially important factor in listening comprehension? While an earlier conceptualization of short-term memory was that it was a limited space in which items of information could be stored, a more recent notion is that we have a mental workspace, "working memory," where we not only store but also manipulate stored information (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980). The storage function of working memory could be measured by having subjects remember lists of digits. In contrast, to tap the processing function of working memory, we might ask subjects to perform mental arithmetic while simultaneously storing the digits. This is similar to what listeners do when they try to comprehend discourse—they must keep information on hand as well as manipulate it. Such storage and manipulation of information is necessary, for example, when a listener correctly refers a pronoun that was just heard to a noun that was heard three sentences earlier. To simulate this requirement of discourse comprehension in a laboratory experiment, we administered the SPIN sentences using a version of a procedure that was developed to measure working-memory span (Daneman & Carpenter, 1980).

Young and old subjects with good hearing listened to the SPIN sentence materials used in the preliminary experiment. This time, in addition to repeating the sentence-final word, subjects were asked to remember it while they continued to listen to the next sentence. The lists of sentences were divided into recall sets of various sizes. We wanted to find out how many of the target words could be remembered during ongoing listening and comprehension. We gave subjects credit for correctly recalling misperceived words, so recall scores were not inflated because words had been misperceived.

There was no difference between the number of words recalled in the quiet condition and the number recalled in the favourable +8 dB S:N condition. (If all the words are recalled then the plots in figures 4 and 5 would be diagonal lines.) In the +5 and 0 dB S:N conditions, which were more taxing (recall that in the earlier perception experiment, we saw benefit due to context under such conditions, suggesting that listening had become effortful), we observed that fewer items were recalled. The plots in Figure 5 for the noisier conditions are depressed compared to the plots shown in Figure 4 for the favourable listening conditions. This pattern indicates that listening in noise takes a toll on working memory. It seems that not only are fewer words heard in noise, but the words that are heard (or misheard) are less available in memory for use in comprehension operations involving the integration of information over time; such integration would be necessary, for example, in listening to a story.

If we wanted to minimize disability, one obvious solution would be to make all listening situations ideal. An ideal listening situation is one where two talkers are speaking in a quiet environment using language that is familiar, simple, and clearly articulated. Unfortunately, even with the help of our engineering colleagues in reducing room noise and reverberation, we would still inevitably be left with other non-ideal characteristics in many everyday listening situations. Listeners often need to understand strangers relaying unfamiliar information spoken with less than perfect articulation in a noisy environment, amidst distractions that divide attention and compete for mental resources.

Figure 4.

Number of words correctly recalled as a function of set size for high-context and low-context sentences presented in quiet and at +8 dB S:N.

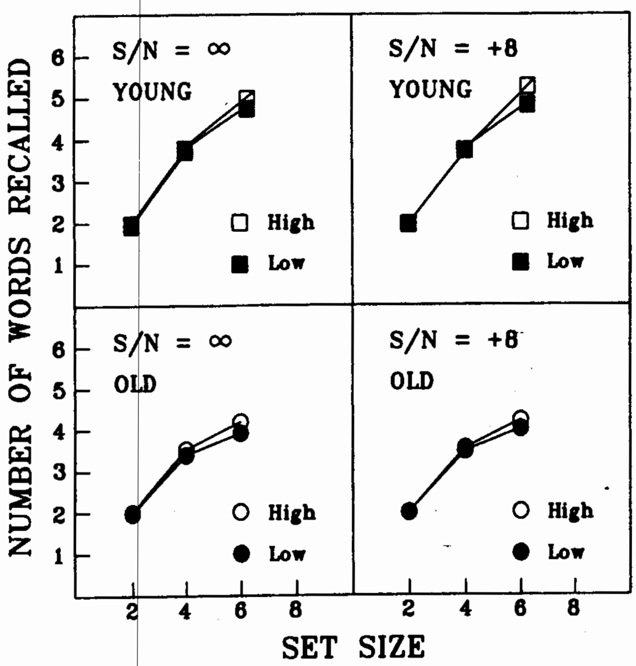
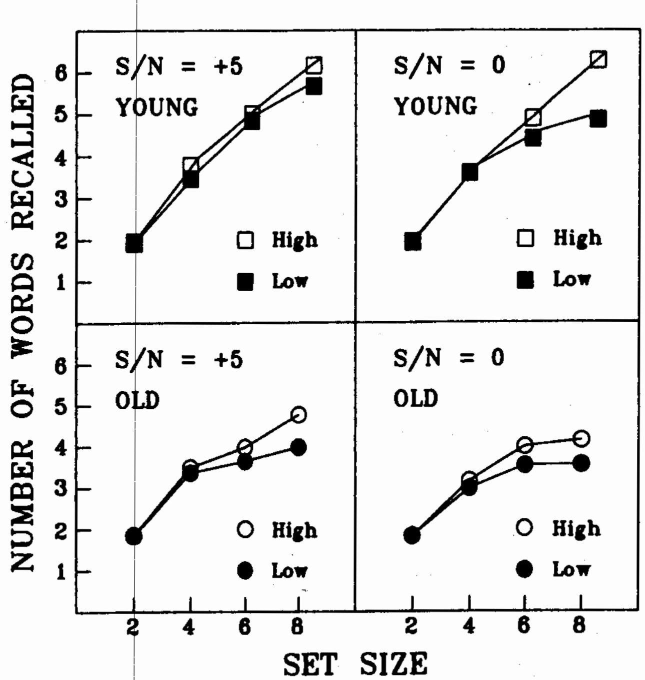


Figure 5.

Number of words correctly recalled as a function of set size for high-context and low-context sentences presented at +5 and 0 dB S:N.



To analyze the dynamics of communication in a way that takes into account the fact that listening often takes place in less than ideal conditions, I adopted a very simple model of communication, where communication is seen as an exchange of a message for a purpose between a talker/sender and a listener/receiver in an environment/context; of course, the roles of the communication partners are interchanged from time to time (for a discussion of this type of model, see Erber, 1988). It is important to remember that hard-of-hearing people are talkers as well as listeners, and that they can control the flow of information, the nature of the content, and the quality of the physical speech signal through the use of diverse discourse-manipulating strategies (see Johnson & Pichora-Fuller, this issue).

Experiences of Hard-of-Hearing Individuals

Let's step for a moment into the shoes of a hard-of-hearing person who is not an engineer, not an audiologist, not a psychologist, not a linguist, and not an anthropologist. How do non-expert people experience hearing to comprehend? Consider a message that was given to me from a senior with a hearing loss, following a talk that I gave in 1992 at a meeting of the Canadian Hard of Hearing Association, about hearing rehabilitation for seniors.

> "When you are hard of hearing:
> 1. You struggle to hear;
> 2. When you struggle to hear you get tired;
> 3. When you get tired you get frustrated;
> 4. When you get frustrated you get bored;
> 5. When you get bored you quit.
> N.B. I didn't quit today."

Also consider the unsolicited observations that a subject who was participating in hearing experiments brought to me at the lab one day.

> "For me, distinct enunciation helps greatly. In completely sounding each word, the speaker goes more slowly and therefore gives the recipient time to assimilate and adapt the sounds to meaning. When asking for repetition of statements it seems to be a way of giving the brain cells time to put sounds into meaning. Also, I find,[to use a photographic term, that I have a very shallow depth of field and sounds are soon out of focus. Most TV or radio speakers are too fast and while I am trying to make sense of the first statement they are away onto the third or fourth sentence so I soon have to drop out and so lose interest. I can appreciate young children being considered inattentive or disruptive in school from this lack of hearing and assimilation and not comprehending why because they don't know that they can't hear." ML, 1992.

This subject was a senior with a hearing loss who had worn a hearing aid for many years. She had worked her life in the post office. It is clear that these non-professionals have arrived at insights that agree with the results of the experiments described above where subjects listened to speech in noise.

My interests next turned to how adults with acquired hearing loss come to understand the nature of their problem—their impairment, their disability, and their handicap. One generalization might be that for professionals, impairment is well understood, easily quantified, and easily talked about, but the basic nature of impairment is not at all obvious to the hard-of-hearing person. In contrast, handicap is elusive to the professional while it is well-known to the hard-of-hearing person who experiences it.

Much of the therapy done by rehabilitative audiologists entails rendering conscious the usually unconscious, automatic language processes of normal-hearers, so that hard-of-hearing individuals and their communication partners can employ deliberate compensatory strategies in situations where they no longer enjoy the automatic and effortless comprehension of spoken language that is enjoyed by normal-hearing listeners. This is somewhat analogous to teaching an adult a second language; while a child learns a native language in the absence of formal instruction, adults often learn second languages through formal instruction, in which the learner is made unnaturally conscious of the rules of language. Also, some adults do not need such formal instruction and learn second languages well simply by immersion; likewise, some hard-of-hearing adults do not require or seek therapy.

At any rate, because clinicians and hard-of-hearing people need to find a common ground on which to understand these matters if therapy is to proceed, it seemed important to investigate the meta-communication knowledge of hard-of-hearing people. Part of the study of meta-communication knowledge that I conducted (an adaptation of the test of meta-communication knowledge described by Erber, 1988) focused on investigating how hard-of-hearing people attributed communication problems to potential sources. Of course, clinicians usually assume that only after the source of a problem is identified will a person be able to select and implement an appropriate solution or compensatory strategy (for example, see Erdman, 1993). Therapy is assumed to be doomed if the person cannot first correctly identify the source of difficulty. But we should not assume too quickly that all people have a sufficient level of meta-communication knowledge to be able to identify the potential sources of communication breakdown. For example, time and time again, I was surprised that many of the people who participated in my aural rehabilitation groups were in fact unaware that at least some of their difficulty arose because of such factors as poor acoustical conditions; they seemed to be almost totally unaware of the acoustical environment. Where we describe hearing loss as the invisible handicap, others have described acoustics as the invisible environment. Likewise, we should not make assumptions about knowledge of other factors that are likely to affect communication.

Study of Source Attribution for Problems Understanding Speech

Method

To investigate meta-communication knowledge, eight scenarios depicting communication difficulty were presented to subjects (see Table 2). Data will be presented for six young (mean age = 24 years, SD = 3 years) and six old subjects (mean age = 68 years, SD = 3 years) with no clinically significant hearing impairment, and for six presbycusic subjects (mean age = 77 years, SD = 6 years). Subjects were instructed as follows: "A person in this situation [one of the scenarios listed in Table 2], is having trouble understanding what is being said. Tell me all of the reasons you can think of why that might be so." The scenarios were presented one at a time, with a simultaneous spoken and written presentation. Phrases such as "Can you think of any more reasons?" were used by the experimenter to prompt subjects to provide any additional sources that

Table 2. List of Scenarios Employed in the Test of Meta-Communication

Questions asked of subjects:
"Why might a listener have trouble understanding what was being said in the following situations?"
1. At a New Year's Eve party
2. At a committee meeting taking place in a board room
3. At a public lecture
4. Watching a film about the biophysics of the inner ear
5. Driving in heavy traffic with a talkative passenger
6. Counting election ballots while someone approaches talking
7. At dinner with a very good friend following a day of Christmas shopping
8. On the telephone

came to their mind. If a response seemed vague or ambiguous, the subject was asked, "What do you mean by that?" No time limit was imposed. When a subject was not able to generate any additional sources, the next scenario was described. All problem sources generated by the subjects were audio-recorded for later transcription and analysis.

The tape-recorded responses were transcribed by a research assistant (author RK). The research assistant had normal hearing, had never worked with hard-of-hearing people, and had never received any instruction in audiology, although she had completed a graduate degree in psycholinguistics. After transcribing the responses, the research assistant then divided the transcript into response units, with each response unit corresponding to a single problem source. She was told that the main categories were divided according to whether the source of the problem was primarily the listener, the talker, the environment, or the message; however, no further information was given about how to categorize the responses. She then categorized the responses according to these four main categories. Subsequently, she sub-categorized and labelled the responses such that each response unit was assigned one label and was categorized as a member of one sub-category (see Appendix for a list of the sub-categories and labels). She completed the first pass at sorting and categorizing the responses with minimal instruction. The investigator encouraged her to establish her own groupings of responses, rather than trying to restrict her to abide by any pre-determined categorization scheme while she tried to capture the similarity and differences of responses represented in the sample. The category and sub-category labels and the rules for assigning responses to categories and sub-categories were, therefore, developed in an iterative fashion with repeated consultation between the research assistant and the investigator. The process was considered to be complete when the research assistant and the investigator reached agreement on the classification of all responses.

Results

A total of 583 responses were generated; 177 (median = 27; range = 18 to 44) by the young subjects, 235 (median = 41; range = 13 to 53) by the old subjects with good hearing, and 171 (median = 29; range = 14 to 36) by the presbycusics. It is important to note that, overall, the old subjects generated just as many responses as the young subjects, with the old subjects with good hearing generating many more responses than the young subjects, and the presbycusics generating only slightly fewer responses than the young subjects.

The breakdown of responses according to the main categories of problem sources is shown in Table 3. For the young subjects, environmental problem sources accounted for the greatest number (98 or 55%) of the responses that were generated, followed by sources related to the listener (58 or 33%), followed by sources related to the talker (18 or 10%), followed by aspects of the message that could not be clearly assigned to either the listener or the talker (3 or 2%). The pattern of responses generated by presbycusics was much like the pattern generated by the young subjects, with the leading category of responses (81 or 47%) being environmental sources, followed by listener-related sources (61 or 36%), followed by talker-related sources (25 or 15%), followed by message-related sources (4 or 2%). Although the general pattern of responses was similar for the young and presbycusic groups, in comparison with the young subjects, the presbycusics attributed fewer (8% less) problems to environmental sources, whereas the proportion of their responses attributed to communication sources was greater, with 3% more responses in the listener category and 5% more responses in the talker category. In comparison to young subjects and presbycusic subjects, the old subjects with good hearing generated many more responses and the pattern of responses differed markedly. In particular, the old subjects with good hearing generated many more responses (105) where problems were attributed to listener-related sources and a higher proportion (46%) of their responses fell into this category rather than into the other three main categories. The number of their responses attributing problems to environmental sources was similar to the number generated by the other two groups (85) but, unlike the findings for the other two groups, the proportion of the responses for the old group with good hearing that fell into this category (36%) was less than the proportion of responses that were attributed to listener-related sources. Like the other two groups, old subjects with good hearing attributed problems less frequently to talker-related sources (34 or 15%) or message-related sources (11 or 5%) than to the listener-related or environmental sources. Compared to the presbycusic group, the old subjects with good hearing generated about the same number of talker-related responses and they generated 3% more responses attributing problems to message-related sources.

Table 3. Breakdown of Total Number of Responses According to Main Problem Source Categories

Group	Sources	Communication		
	Environment	Listener	Talker	Message
Young	98 (15; 11 to 27)	58 (11; 6 to 16)	18 (3; 0 to 6)	3 (0; 0 to 2)
Old	85 (17; 1 to 23)	105 (18; 7 to 26)	34 (5; 2 to 13)	11 (2; 0 to 3)
Presbycusic	81 (9; 6 to 28)	61 (10; 5 to 16)	25 (5; 0 to 7)	4 (0; 0 to 3)

Note. Median and range are shown in parentheses.

Each subject was categorized according to whether they attributed problems more often to environmental sources or to communication sources (listener-, talker- and message-related sources). All young subjects attributed problems more to environmental sources. For the old subjects with good hearing and the presbycusics, about half of the subjects attributed problems more to environmental sources (three in the old group and two in the presbycusic group) and about half attributed problems more to communication sources (three in the old group and four in the presbycusic group). In summary, in comparison to young subjects, old subjects generated at least as many responses but they attributed problems in comprehending spoken language less often to environmental sources and more often to problems arising from communication, especially to listener-related problems, but also to talker-related problems. Interestingly, old subjects with good hearing were often even more likely than presbycusics to attribute problems to listener-related sources.

The responses generated within each of the main categories were further examined according to the sub-categories and response labels that were created during examination of the data. A taxonomy of the sub-categories and labels that were created is provided in the Appendix. The responses generated by each age group for each of the scenarios will be described for each of the main categories.

Environment

The environmental sources that might contribute to a listener's difficulty in understanding speech were divided into two main sub-categories: problems attributable to the physical environment, and those attributable to technical aspects of signal transmission (see Appendix). The physical environment was further classified into problems with the acoustical environment and problems with the visual environment. When responses were not specific to either the acoustical or the visual dimensions of the environment, they were classified as "general" problems with the physical environment. Likewise, technical problems were also classified into acoustical, visual, or general problems.

For all groups, most of the environmental problem sources that were generated related to specific acoustical or more general features of the physical environment. Not surprisingly, responses describing various types of competing acoustical sources were generated, including competing speech in multi-talker situations, competing non-speech noise originating from inside and outside sources, and unfavourable acoustical characteristics of rooms (see Table 4). For the eight different scenarios (see Table 5), problems were attributed to specific acoustical or more general features of the physical environment most often for the party and public lecture situations (45 responses each), followed by the driving situation (36 responses), the committee meeting situation (31 responses), the telephone situation (24 responses), the dinner situation (18 responses), and the ballot-counting and film-viewing situations (11 responses each). It is noteworthy that the characteristics of the room were mentioned only for the public lecture (9 responses), the committee meeting, and the film-viewing situations (2 responses each). In contrast to the large number of responses which identified acoustical problem sources, very few responses attributed problems solely to the visual environment. Perhaps surprisingly, young subjects mentioned the visual environment more often than did old subjects.

Table 4. Number of Responses for Sub-Categories of Environmental Problem Sources by Group

Group	Sub-Category Physical General	Acoustical	Visual	Technical General	Acoustical	Visual
Young	29	48	4	6	7	4
Old	37	40	1	4	1	2
Presbycusic	22	44	2	6	7	0

Table 5. Number of Responses for Sub-Categories of Environmental Problem Sources by Scenario

Scenario	Sub-Category Physical General	Acoustical	Visual	Technical General	Acoustical	Visual
Committee meeting	21	10	1	0	1	0
Counting ballots	5	6	1	0	0	0
Dinner	7	11	0	0	0	0
Driving	10	26	1	0	0	0
Film	4	7	2	4	6	1
Party	15	30	1	0	0	0
Public lecture	21	24	1	0	5	0
Telephone	6	18	0	12	3	5

Listener

The listener-related sources that might contribute to difficulty in understanding speech were divided into three sub-categories: perceptual, cognitive, and state of the listener. For all groups, most responses by far attributed problems in understanding speech to the state of the listener (see Table 6); for example, lack of motivation, lack of interest, lack of attention, divided attention, fatigue, emotional stress, or inebriation (see Appendix). The next most frequently generated problem source was the listener's cognitive status; for example, lack of knowledge, inability to use context resulting in wrong expectations, poor ability to anticipate or plan, inappropriate culture-specific schema, or difficulty with complex tasks. In general, problems that

Table 6. Number of Responses for Sub-Categories of Listener-Related Problem Sources by Group

Group	Sub-Category Perceptual	Cognitive	State
Young	2	12	44
Old	10	23	72
Presbycusic	6	14	41

seemed to be transient (such as inebriation) were classified in the state category, whereas problems that were a more permanent characteristic of the listener (such as lack of knowledge) were classified in the cognitive category. Most importantly, although there were many responses generated that attributed problems to the listener's cognitive abilities or state, there were very few responses that attributed problems to perceptual difficulties, such as hearing or vision problems.

The young and presbycusic subjects generated approximately the same number of responses attributing problems to the listener's cognitive abilities or state; however, the old subjects with good hearing generated almost twice as many responses attributing problems to these factors. There was less difference between the two old groups in terms of the proportion of responses attributing comprehension difficulty to the listener's perceptual problems. Importantly, both of the old groups generated more responses in the perceptual sub-category than did the young group. In general, subjects did not often attribute a listener's difficulty comprehending spoken language to perceptual factors, but young subjects were less likely to generate this category of response than were old subjects, whether or not the old subjects had a hearing loss themselves.

Cognitive problem sources were generated twice as often for the film-viewing situation (20 responses) as for the public lecture or committee meeting situations (11 responses each). Cognitive problem sources were generated much less often for the telephone situation (five responses); no other situation accounted for more than two responses in this sub-category. Not surprisingly, it seems that the situations where a listener's cognitive abilities are considered to be most important are those in which information is likely to be dense, unfamiliar, and untailored to the listener as an individual (see Table 7).

Listener state was generated as a problem source more than twice as often for the dinner situation (47 responses) than for any situation. For the dinner situation, fatigue accounted for about a third of the responses, divided attention for almost a third, and motivation to communicate for about a fifth. Listener state was also considered to be an important source of difficulty in the ballot-counting situation (24 responses), followed by the driving situation (19 responses),

Table 7. Number of Responses for Sub-categories of Listener-Related Problem Sources by Scenario

Scenario	Sub-Category Perceptual	Cognitive	State
Committee meeting	3	11	11
Counting ballots	1	1	24
Dinner	0	0	47
Driving	4	0	19
Film	2	20	18
Party	2	2	18
Public lecture	3	11	10
Telephone	3	5	12

and the film-viewing and party situations (18 responses each). The major reason for difficulty in the ballot-counting (18 of 24 responses) and driving situations (17 of 19 responses) was divided attention. Predictably, inebriation accounted for half of the problems encountered in the party situation. Listener state was generated less often for the telephone situation (12 responses), the committee meeting situation (11 responses), and the public lecture situation (10 responses).

Most importantly, perceptual problem sources were seldom generated; they accounted for only about 3% of all responses. The responses in this sub-category were distributed fairly evenly for the scenarios, with the driving situation prompting the most responses (4) in this category, and the dinner situation being the only situation that did not prompt even one response in this sub-category. Of the 18 responses that were generated in this sub-category, fully 15 referred to hearing loss. Only one, in the driving situation, referred to the listener not looking at the talker's face.

Talker

The talker-related sources that might contribute to a listener's difficulty in understanding speech were divided into three sub-categories: problems attributed to the talker's articulation of speech, the talker's cognitive abilities, or the talker's emotional state (see Appendix). For all groups, problems arising from the poor articulation of the talker were generated far more often than were cognitive or emotional sources (see Table 8). Nevertheless, it is noteworthy that some subjects did feel that the cognitive or emotional status of the talker could be a source of difficulty for the listener.

The old subjects reported poor articulation to be a problem source almost twice as often as did the young subjects, and this source was reported more frequently by the presbycusics (11% of all their responses) than by the old

Table 8. Number of Responses for Sub-Categories of Talker-Related Problem Sources by Group

Group	Sub-Category Articulatory	Cognitive	State
Young	11	3	4
Old	17	7	10
Presbycusic	19	1	5

subjects with normal hearing (7% of all their responses). At first glance, it may seem that this pattern is reminiscent of the frequent complaint of hard-of-hearing people that talkers mumble; however, unclear speech was the topic of less than half of the responses that were categorized as problems of articulation. Curiously, poor articulation was seldom reported as a problem source for five of the eight scenarios (see Table 9), but it was frequently generated for the other three sources: the telephone situation (17 responses), the committee meeting situation (11 responses), and the public lecture situation (10 responses). The latter are all situations in which there is usually one talker and relatively little background noise, with signal degradation likely being caused by less obvious factors such as reverberation, distance between the talker and listener, or variable quality of signal transmission in the telephone line or by a PA system. This curious scenario-specific generation of articulation as a problem source suggests that the subjects may have mis-attributed the difficulties experienced in these situations to the talker, when environmental sources may be contributing significantly but less obviously to difficulty understanding speech. Alternatively, the pattern may suggest that talker-related problem sources become important only when they co-occur with these particular environmental problem sources. This alternative interpretation is supported to some extent by the fact that broken or faulty equipment was generated as a problem source most often for the telephone situation, and room acoustics was generated as a problem source most often for the public lecture situation, although it was generated much less often for the committee meeting situation.

Table 9. Number of Responses for Sub-Categories of Talker-Related Problem Sources by Scenario

Scenario	Sub-Category Articulatory	Cognitive	State
Committee meeting	11	1	0
Counting ballots	2	0	0
Dinner	2	1	4
Driving	1	0	1
Film	2	2	0
Party	2	0	12
Public lecture	10	4	0
Telephone	17	2	2

The old subjects with good hearing generated problem sources related to the cognitive and emotional status of the talker about twice as often as did either the young or the presbycusic subjects (see Table 8). Problems attributed to cognitive status were generated most often in the public lecture situation (four responses), followed by the film-viewing and telephone situations (two responses each), and by the committee meeting and dinner situations (one response each). This ordering of situations seems to correspond with the likely importance of the talker's knowledge of the topic, the talker's ability to convey information, the familiarity of the information to the listener, and the familiarity of the talker with the listener. For example, in the public lecture situation, the talker's knowledge of the topic and ability to convey information is very important, especially since the listeners are numerous and unfamiliar to the talker and the listeners' degree of familiarity with the topic is probably unknown to the talker. In contrast, in the dinner situation, the talker and listener are familiar with each other and presumably with the topics of their conversation. Not surprisingly, problems attributed to emotional status were generated most often for the New Year's party situation (12 responses).

Message

Very few responses were classified as message-related problem sources because, whenever possible, responses were assigned to either the talker or the listener category (see Table 10). Therefore, the only responses that were classified as message-related problem sources were those that could not be assigned specifically to the listener or the talker. It is also important to note that careful attention was paid to the words chosen by the subject. For example, if the subject said that "the talker was boring" or "the talker was uninteresting" then the response was coded as a talker-related problem; if

Table 10. Number of Responses for Message-Related Problem Sources by Scenario

Scenario	Number of responses
Committee meeting	7
Counting ballots	0
Dinner	0
Driving	0
Film	4
Party	1
Public lecture	1
Telephone	4

the subject said that "the listener was bored" or "the listener was uninterested" then the response was coded as a listener-related problem; if the subject said that "the information was boring" or "the information was uninteresting" then the response was coded as a message-related problem. The comments that were phrased to pinpoint the message without referring to the listener's or the talker's perspective were most numerous for the committee meeting situation (seven responses), followed by the film-viewing situation and the telephone situation (four responses each), and the public lecture and party situations (one response each). What these situations seem to have in common is that there is one talker and multiple listeners who are not necessarily familiar with each other (even in the case of the telephone situation, these responses were usually generated when subjects had telephone advertising in mind as opposed to personally significant conversations). It is interesting that the situations for which there were no message-related comments were situations with one-to-one, face-to-face interactions.

Discussion

The present meta-communication study strongly demonstrates that people, young or old, who have normal hearing or who are hard of hearing, almost always attribute the disability characterized by difficulty understanding speech to sources other than hearing loss. Surprisingly, perceptual problem sources accounted for less than 3% of the total number of responses. When hearing loss was generated as a problem source, it was usually generated by the old subjects, either those with normal hearing or those with hearing loss. It is interesting that about half of the old subjects, whether they had normal hearing or impaired hearing, attributed problems more often to communication-related sources than to environmental sources, but that all of the young subjects attributed problems more often to environmental sources than to communication-related sources. As a group, the old normal-hearing subjects were unique in attributing problems more often to listener-related sources than to environmental sources, but it was the listener's cognitive ability and state, and not the listener's perceptual limitations, that accounted for most of the listener-related problem sources. It is also interesting that the old subjects with good hearing generated a far larger number of problem sources than did the young or presbycusic subjects. It seems likely that the young subjects generated fewer problem sources simply because they have less experience with communication problems. It is possible that the presbycusic subjects offered hearing loss as a problem source and ceased to consider the great variety of other possible sources that were generated by their age-matched peers. Such an interpretation would be consistent with clinical observations that hard-of-hearing individuals sometimes seem to fail to realize that even normal-hearing listeners sometimes have trouble understanding what is said and that perfect speech understanding in all conditions is not a realistic expectation for anyone.

Conclusion

The present set of experimental results seem to echo the unsolicited observations of the two hard-of-hearing informants. In retrospect, perhaps it is not as surprising as it at first seemed that people have very little awareness and do not often attribute problems in comprehending spoken language to hearing loss per se. As listeners who are having trouble understanding speech, hard-of-hearing people, like normal-hearing people listening in less than ideal conditions, experience the fatigue, stress, and uncertainty that comes with effortful listening. It seems that the psychological toll arising from hearing loss is obvious to most people, including the hard of hearing, whereas the absence of outer hair cell #4,592 or a 40 dB HL elevated pure-tone threshold at 2000 Hz is rarely apparent—even though hearing loss may indeed be the underlying source of the problem. The attribution of problems to sources, the arena in which people look for solutions, and ultimately, the indicators of what is a successful solution are clearly very different for a laboratory-thinking clinician than for a person who lives with a hearing loss or in an acoustically hostile world. The challenge for the rehabilitative audiologist and the hard-of-hearing individual is to sort out how much of the disability is directly attributable to hearing loss, how much is secondary and only indirectly attributable to it, and how much is, in fact, attributable to other sources that affect normal-hearing listeners, albeit perhaps to a lesser extent.

Another important conclusion of the study is that the disability characterized by difficulty understanding speech is clearly modulated in a situation-specific manner. The fact that disability and handicap are modulated by the non-auditory problem sources and that these problem sources are featured differently in various situations explains, at least to some extent, why these phenomena are so confusing to hard-of-hearing people as well as to their communication partners, and why they are so elusive to the clinician who is attempting to quantify them. Each situation prompted the generation of a unique profile of problem sources. Specifically, the New Year's party and the public lecture scenarios (followed closely by the driving scenario) evoked the most responses attributing problems to environmental sources; the film-viewing scenario evoked the most responses attributing problems to the listener's cognitive abilities; the dinner scenario evoked the most responses attributing problems to the listener's state; the telephone scenario evoked the most responses attributing problems to the articulation of the talker; the public lecture scenario evoked the most responses attributing problems to the cognitive abilities of the talker; the New Year's party evoked the most responses attributing problems to the talker's emotional state; and the committee meeting scenario evoked the most responses attributing problems to the message. There was also a suggestion that for the communication-related problem sources, the attribution of the problem to the listener, the talker or the message itself depended on whether or not the scenario featured one-to-one, face-to-face, or personally significant communication, as opposed to one-to-many, more anonymous communication. Problems related to the listener's state were generated more often for the former type of communication, whereas the listener's cognitive abilities and message-related and talker-related sources were generated more often for the latter type of communication.

If a larger set of scenarios were employed or the personal relationships of the communicators depicted in the scenarios were altered (for example, a telephone call from a close family member vs. one from a potential employer vs. one from a market research company), it is possible that other problem sources might emerge or that the attribution of problems to sources might shift. While some questionnaires used by rehabilitative audiologists probe the extent to which difficulty comprehending spoken language is experienced in various situations (for example, *The Hearing Performance Inventory*, Giolas, Owens, Lamb, & Schubert, 1979 or *The Communication Profile for the Hearing Impaired*, Demorest & Erdman, 1986), and other questionnaires probe the psychological and social impact of hearing loss (for example, *The McCarthy-Alpiner Scale*, McCarthy & Alpiner, 1983 or *The Hearing Handicap Inventory for the Elderly*, Ventry & Weinstein, 1982), it seems that a more integrated approach such as the one used in this study may be an important addition to the clinical toolkit. A meta-communication task such as the one employed in the present study could be used to gain insight into the specific constellations of problems that are perceived to give rise to disability in specific situations. In addition to learning that a person experiences difficulty understanding in a set of situations, or that he or she experiences social or psychological handicap, we may also benefit from being able to map variations in disability and handicap onto different situations by pinpointing how the person attributes his or her disability or handicap to situation-specific problem sources in a variety of real-world situations.

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Appendix

Taxonomy of Problem Sources for Difficulty in Understanding Speech

Environment-Physical-General

1. distance and/or obscurity of talker
2. distractions (other than "people talking" but including "people moving about")
3. many people
4. features of room

Environment- Physical-Acoustical

5. multiple talkers
6. background noise (for example, in room, in car)
7. outside noise
8. general noise level
9. acoustics

Environment-Physical-Visual

10. source not visible

Environment-Technical

11. broken or faulty equipment

Environment-Technical-Acoustical

12. sound quality of equipment

Environment-Technical-Visual

13. visual cues impeded

Listener-Perceptual

14. hearing loss
15. dialect
16. wearing walkman
17. not looking at face of talker

Listener-Cognitive

18. difficulty understanding
19. difficulty with topic/task
20. ethnic/cultural influences
21. anticipation/planning/expectation

Listener-State

22. not attending
23. boring, dull, not interesting (topic, conversation, film, task)
24. divided attention: concentrating on something else
25. tired, sleepy
26. emotional state
27. motivation to communicate
28. drunk

Talker-Articulatory

29. clarity of speech
30. accent
31. loudness
32. talker turning away
33. annoying mannerisms

Talker-Cognitive

34. ability of talker to explain
35. talker doesn't know subject
36. talker wrongly assumes listener possesses knowledge
37. talker style (cultural, etc.)

Talker-State

38. talker not attending
39. slurring (mouth full of food)
40. drinking
41. emotional state
42. tired

Message-Content

43. message not clear
44. language used
45. dry information