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Unilateral Deafness in Adults: Effects on Communication and Social Interaction

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Objectives: The aim of this study was to explore the self-reported consequences of profound unilateral deafness regarding communication and social interaction and to compare subjects' speech perception scores to those of normal-hearing individuals who were rendered temporarily unilaterally deaf.

Methods: Cross-sectional data from 30 individuals with unilateral deafness and 30 individuals with normal hearing (age, 14 to 75 years) were obtained through structured interviews and tests of audiovisual, auditory-only, and visual-only speech perception.

Results: In individuals with permanent unilateral deafness, 93% reported that hearing loss affected communication. Eighty-seven percent reported problems with speech perception in noisy settings. Other consequences were feelings of exclusion, reduced well-being, and extensive use of speech perception strategies. Inducing temporary unilateral deafness (through short-term blocking of one ear) in normal-hearing subjects produced similar effects on speech perception (27% score) as those experienced by unilaterally deaf subjects (25% score).

Conclusions: Individuals with unilateral deafness experienced a significant disability in auditory function that affected their communication and social interaction. The major challenges were communicating in situations with background noise, in poor acoustic surroundings, and with limited access to speech-reading or direct listening. Under certain listening conditions, long-standing unilateral deafness seemed to yield no advantage over temporary deafness on one side.

Key Words: auditory rehabilitation, quality of life, self-rated hearing difficulty, speech perception, unilateral deafness.

INTRODUCTION

Previous research has demonstrated that unilateral deafness can be experienced as a significant disability that causes difficulty with communication and speech perception, especially in environments with noise and in poor acoustic conditions.[1-5] Bateman et al[3] found deficits related to auditory dysfunction in 72% of their patients with unilateral deafness following acoustic neuroma surgery. Hansson[1] found audiological, psychosocial, and existential consequences of unilateral deafness, indicating that individuals with unilateral deafness experienced increased stress levels and a feeling of exclusion in social settings. There is further evidence that moderate to severe unilateral hearing loss can have negative consequences for children in educational settings.[6-9] Colletti et al[10] confirmed the superiority of binaural versus monaural hearing, but they did not find significant differences between binaurally and monaurally hearing subjects in areas of educational, social, and employment achievement.

Hearing problems in unilaterally deaf individuals are often explained by the lack of binaural summation, the implications of the head shadow effect, and the inability to utilize intensity and time or phase differences that would be apparent were the signals entering two ears instead of one.[11,12] Lacking the advantages of binaural hearing, these individuals face difficulties with speech perception on the deaf side, difficulties with sound localization, and difficulties with speech perception in groups or with background noise in trying to segregate the signal from the noise. Earlier studies have confirmed that these difficulties can result in communication distress when unilateral deafness occurs after surgery, such as acoustic neuroma surgery or surgery for a vestibular schwannoma.[3,5] Several studies have confirmed that children with moderate to severe unilateral hearing loss are at risk for educational delays.[8,9] There is, however, less information regarding the effects of unilateral deafness on communication in adolescents and adults, particularly with respect to social interactions and psychosocial consequences.

The main aim of this study was to explore the self-reported consequences of profound unilateral deafness in adolescents and adults regarding communication and social interaction in everyday situa-

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TABLE 1. DEMOGRAPHIC INFORMATION ON 30 PARTICIPANTS WITH UNILATERAL DEAFNESS

Sex	*Cause*	*Side of Deafness*	*Tinnitus*	*Age (y)*	*Age at Deafness (y)*	*Duration of Deafness (y)*	*Visual-Only SP*	*Auditory-Only SP*	*Audio-visual SP*
F	Acoustic neurinoma	R	Yes	36	32	4	21%	53%	90%
M	Acoustic neurinoma	R	Yes	51	43	8	3%	20%	79%
F	Malformation	R	No	20	0	20	1%	28%	93%
F	Malformation	R	No	15	0	15	5%	66%	92%
F	Measles	R	No	48	6	42	12%	18%	75%
F	Meniere's disease	R	Yes	57	42	15	23%	40%	77%
F	Meniere's disease	L	Yes	58	36	22	2%	9%	75%
M	Meningitis	R	No	63	6	57	17%	0%	52%
M	Mumps	R	No	23	8	15	8%	18%	95%
M	Mumps	L	Yes	19	12	7	5%	20%	83%
M	Mumps	L	Yes	51	15	36	5%	8%	59%
F	Mumps	L	No	27	2	25	10%	26%	63%
M	Mumps	L	No	55	16	39	21%	35%	93%
F	Otitis media	L	No	63	4	59	16%	6%	64%
F	Otitis media	R	No	49	12	37	19%	24%	82%
F	Rubella	L	No	16	1	16	12%	30%	92%
F	Sudden deafness	L	Yes	32	29	3	5%	10%	91%
F	Sudden deafness	L	Yes	63	58	5	0%	2%	26%
F	Sudden deafness	R	Yes	47	43	4	13%	17%	85%
M	Trauma	R	No	51	0	51	0%	39%	88%
M	Trauma	L	Yes	25	6	19	7%	15%	60%
M	Trauma	R	Yes	44	36	8	4%	38%	82%
F	Trauma	R	Yes	43	4	39	28%	29%	96%
F	Trauma	L	Yes	75	13	62	15%	2%	83%
M	Unknown	L	Yes	67	0	67	24%	12%	88%
M	Unknown	R	Yes	49	0	49	15%	39%	100%
M	Unknown	R	No	29	0	29	37%	42%	88%
M	Unknown	L	No	34	0	34	30%	39%	93%
M	Unknown	L	No	14	0	14	6%	14%	79%
F	Unknown	R	Yes	32	0	32	12%	44%	91%
	Average			41.9	14.1	27.8	13%	25%	80%
	SD			17.3	17.1	19.2	9.6	16.26	15.98
	Minimum			14.0	0.0	3.0	0.0	0.0	26.0
	Maximum			75.0	58.0	67.0	37.0	66.0	100.0

SP — speech perception.

tions. The matters of particular interest were as follows: 1) To what degree is unilateral deafness experienced as a communication handicap affecting social interaction? What are the major areas of difficulty, and what are the psychosocial consequences? 2) To what extent do people with unilateral deafness use strategies to compensate for their hearing loss in social interactions? 3) In those with unilateral deafness, is there a relationship between self-reported speech perception in noisy settings and measured speech perception in such settings? 4) Is it possible to "learn" to hear better in noise over time as one's experience with unilateral deafness grows?

METHODS

Participants. The study sample consisted of 30 profoundly unilaterally deaf adolescents and adults (16 women and 14 men; ages, 14 to 75 years; mean age, 42 years). Table 1 provides an overview of the subjects' demographic information. Pure tone air conduction threshold testing was conducted and showed a hearing threshold in the poor ear of more than 60 dB hearing level at the frequencies 250 to 6,000 Hz. The ear with normal hearing conformed to ISO (International Organization for Standardization) standard 7029:1992 for normal air conduction hearing thresholds. A masking level of 70 dB was used in the hearing ear to detect the hearing level of the deaf ear.[13] Sixteen participants had right-sided deafness, and 14 had left-sided deafness. The subjects' mean (±SD) duration of deafness was 28 ± 19 years (range, 3 to 67 years). On the basis of informa-

TABLE 2. QUESTIONS AND RESULTS RELATED TO COPING WITH UNILATERAL DEAFNESS

Coping	*No Degree*	*Small Degree*	*Some Degree*	*Large Degree*	*N*
To what degree would you consider yourself as handicapped in communication situations?	7%	37%	43%	13%	30
Would you, because of your hearing loss, avoid situations like meeting with friends in a crowded, noisy restaurant with background noise, music, and several people speaking at the same time?	60%	0%	27%	13%	30
To what degree would you feel excluded in an unstructured conversation with several known speakers in an otherwise quiet room?	7%	40%	40%	13%	30
To what degree would you feel excluded in an unstructured conversation with several unknown speakers in an otherwise quite room?	0%	23%	40%	37%	30
To what degree do you think unilateral deafness has had an effect on your feeling of well-being at school?	32%	27%	27%	14%	22
To what degree do you think unilateral deafness has had an effect on your feeling of well-being at work?	42%	23%	19%	16%	26
To what degree do you think unilateral deafness has had an effect on your participation in classroom discussions?	36%	14%	41%	9%	22
To what degree do you think unilateral deafness has had an effect on your participation at work in discussions affecting your work career?	58%	12%	15%	15%	26
To what degree do you think unilateral deafness has had an effect on your performance at school?	41%	18%	36%	5%	22
To what degree do you think unilateral deafness has had an effect on your performance at work?	54%	27%	15%	4%	26

tion from the participants, 10 were assumed to have congenital unilateral deafness, and 20 had acquired unilateral deafness during childhood (12 subjects) or between the ages of 29 and 58 years (8 subjects). Among those with congenital hearing loss, 30% of cases were from an unknown cause. Among those with acquired hearing loss, the most frequent causes cited were trauma to the head and mumps (Table 1). Fifty-three percent of subjects reported that they had tinnitus, and 9 reported that the tinnitus was continuous during waking hours. Six participants (20%) had been fitted with a hearing aid. The hearing aid fitted was CROS (contralateral routing of signals); however, none of the participants used the hearing aid, except for 1 subject who wore it occasionally in situations such as work-related meetings.

The individuals with unilateral deafness were recruited by use of a newspaper announcement in a rural county located in Buskerud, Norway. The study also included a group of 30 individuals with normal hearing who were used as a reference group for the test of speech perception in noise. These participants were recruited from the same county as the sample group. They were engaged through the participants with unilateral deafness, who were asked to recruit a normal-hearing friend or acquaintance to participate in the study. Pure tone air conduction threshold testing was performed to confirm normal hearing. Besides having similar socioeconomic statuses, the sample and the reference groups were matched on age and sex. Additionally, the reference individuals were made experimentally deaf in the same ear as their matching informant with unilateral deafness. No intelligence tests were conducted; however, the information gathered during the interview about the participants' work and social situations indicated that all were functioning within the normal range. None of the individuals reported any visual acuity problems that hindered their participation in the test situation. All participants signed an informed consent form, and the study was approved by the Data Inspectorate and by the Regional Committee for Medical Research Ethics.

Materials and Procedures. Data from the unilaterally deaf subjects were collected by means of a specially constructed interview and a test of speech perception in noise. The aim of the interview was to obtain numerical self-ratings of the subjects' communication experience in situations known to be challenging for individuals with unilateral deafness. Methodically, this meant that a major part of the interview had a structured set of questions with fixed wordings. Each question had a choice of 3 to 5 fixed alternative answers (for example, no degree, small degree, some degree, and large degree). The interview guide was developed especially for this study, as there existed at the time of the present study few relevant self-rating scales addressing the specific problems of the unilaterally deaf listener. In comparison with questionnaires that became available later, the present interview guide contained questions similar to those presented in the Unilateral Auditory Capacity Assessment Scale.[5]

Tables 2-4 show the main questions from the in-

TABLE 3. QUESTIONS AND RESULTS RELATED TO USE OF SPEECH PERCEPTION STRATEGIES (N = 30)

Strategy Use	*No Degree*	*Small Degree*	*Some Degree*	*Large Degree*	*Totally Dependent*
You are in a room with background noise, participating in an unstructured conversation with multiple speakers. If the speech comes from the same side as your deaf ear, would you turn your hearing ear toward the speaker?	0%	0%	0%	37%	63%
You are in a room with background noise, participating in an unstructured conversation with multiple speakers. To what degree must you look at the face of the one who is speaking in order to follow the conversation?	3%	13%	13%	40%	30%
You are in a room with a long reverberation time, participating in an unstructured conversation with multiple speakers. To what degree must you look at the face of the one who is speaking in order to follow the conversation?	10%	13%	33%	30%	13%
You are in a quiet room, participating in a structured conversation with multiple speakers. If the speech comes from the same side as your deaf ear, would you turn your hearing ear toward the speaker?	17%	10%	27%	37%	10%
You are in a quiet room, participating in a structured conversation with multiple speakers. To what degree do you look at the face of the one who is speaking in order to follow the conversation?	37%	33%	13%	13%	3%

terview and the participants' responses to the questions. The following characteristics were addressed. First, we studied the communication experience and coping strategies used in different interaction situations, eg, the amount of experience communicating with known versus unknown speakers, a sense of well-being in communication, and the amount of participation and performance in communicating (Table 2). Second, degree of strategy use, such as speech-reading and positioning strategies, was examined. The speech-reading strategy involves the use of visual clues, such as movements of the speaker's lips, facial movements, gestures, and body language, to decode the contents of spoken language. A positioning, or head-turning, strategy was indicated by the subject's attempt to achieve direct listening by turning the hearing ear toward the speech source (Table 3). Finally, we examined self-reported speech perception in different acoustic surroundings, such as in quiet surroundings, in the presence of background sound, and in rooms with poor acoustics (Table 4). To ensure that the questions were easily understood, we pretested all questions on individuals with unilateral deafness who were not participating in the study. One researcher conducted all the interviews.

TABLE 4. QUESTIONS AND RESULTS RELATED TO SELF-REPORTED SPEECH PERCEPTION (N = 30)

Speech Perception and Understanding	*Most Words*	*Some Words*	*No Words*	*Often*	*Sometimes*	*Rarely*
You are in a quiet room, participating in a structured conversation where the conversation moves from one person to another. How well do you hear?	100%	0%	0%			
You are in a room with a long reverberation time, as in churches or large halls with brick walls. How well do you hear in a one-on-one conversation?	47%	40%	13%			
You are in a room with a long reverberation time, listening to information given only through loudspeakers. How well do you hear?	37%	40%	23%			
You are in a room with background noise, such as music and several people having different conversations. How well do you hear in a one-on-one conversation?	13%	50%	37%			
You are in a quiet room, participating in a structured conversation where the conversation moves from one person to another. Would you understand the subject matter in the conversation?				100%	0%	0%
You are in a room with a long reverberation time, as in churches or large halls with brick walls. Would you understand the subject matter in a one-on-one conversation?				67%	23%	10%
You are in a room with a long reverberation time, listening to information given only through loudspeakers. Would you understand the subject matter in the conversation?				57%	30%	13%
You are in a room with background noise, such as music and several people having different conversations. Would you understand the subject matter in a one-on-one conversation?				47%	47%	7%

TABLE 5. PATTERN MATRIX FOR CLUSTERED VARIABLES

Variable	*Cluster*	*Variable Name*	*Cronbach's Alpha*
Avoidance strategies	1	Exclusion	0.761
Exclusion in conversation with known speakers	1		
Exclusion in conversation with unknown speakers	1		
Well-being	2	Coping	0.797
Performance	2		
Participation	2		
Speech-reading in noise	3	Speech-reading	0.694
Speech-reading in surroundings with long reverberation time	3		
Speech-reading in silence	3		
Head-turning in noise	4	Head-turning	0.813
Head-turning in silence	4		

Variables are grouped according to cluster to which they are most closely related.

To assess speech perception in noise, we tested both the unilateral and the normal-hearing participants using a Norwegian equivalent[14] of the Iowa sentences list.[15] The sentences were based on an adult-level vocabulary and were developed and adapted from the content of the Bamford-Kowal-Bench (BKB) sentences, based on a standardized speech perception test.[16] In addition to these sentences, we added a noise track consisting of 6-speaker voice babble containing the same sentence material as the BKB test sentences.[14]

The speech was presented at an average level equivalent to 61 dBA (fast meter response). To ensure an appropriate baseline in the experiment (avoiding a "floor and ceiling effect") we adjusted the noise level until we had a signal-to-noise ratio that would make it possible for the normal-hearing reference group to recognize between 50% and 60% of the sentences correctly. At a signal-to-noise ratio of –7.5 dB, the reference group scored within the desired range, with a mean score of 54.7% correct. A signal-to-noise ratio of –7.5 dB was then used in further testing, and the noise level was held constant at 68.5 dBA. The signal-to-noise ratio was defined as the difference between the sound pressure levels from the voice and the noise sources, ie, 61 minus 68.5 dB. To ensure that the binaural group had the smallest advantage possible, we presented the speech and noise signals from a 0° angle (ie, right in front of the person). We chose a 0° angle to explore whether it was possible for people to learn to hear better in a noisy listening situation. This kind of listening situation would imply a binaural summation effect and minimize or exclude the effects of time or intensity differences and of differences between direct and indirect listening.

Each participant was placed in the middle of the room in relation to the side walls and at a 2-m distance from a 21-inch (53 cm) video monitor. Facing the monitor, participants were instructed to repeat each word in the sentences. Guessing was encouraged, and the percentage of correct words was noted. The test was performed in a soundproof room of 4.12 × 2.72 m with a reverberation time of less than 0.4 seconds. Speech perception was tested under 3 conditions: unilateral audiovisual, unilateral auditory-only, and visual-only. The visual information was provided via a video recording of the person speaking that played on the video monitor. In the visual-only condition, the participants only saw the talker producing the sentences, but did not hear the words produced. All test conditions were performed in noise, and the signal-to-noise ratio was the same under all test conditions. To achieve a satisfactory unilateral hearing reduction in the normal-hearing group, we gave the normally binaural subjects both hearing protection (Profex) and earplugs (E-A-R taper fit) inserted into the ear. The hearing reduction achieved with this form of blocking was measured to an attenuation of 40 to 65 dB at the frequencies 250 to 6,000 Hz.

Statistics. Descriptive statistics were used to report the characteristics of the individuals who were unilaterally deaf. Both Pearson and the nonparametric Spearman correlation coefficients were utilized to examine the relationships among study variables. Student's *t*-test, the Mann-Whitney U test, and the Wilcoxon signed-rank test were used to compare results between and within groups. Two-tailed tests of significance were used, and the level of significance was set to a p value of 0.05 or less (without correction for multiple testing). Eta squared was used to estimate the effect size. To explore the potential structures or patterns that might appear in the multivariate data collected in the interviews, we performed a hierarchical cluster analysis using a between-group linkage cluster method and a squared Euclidean distance measure after standardizing all

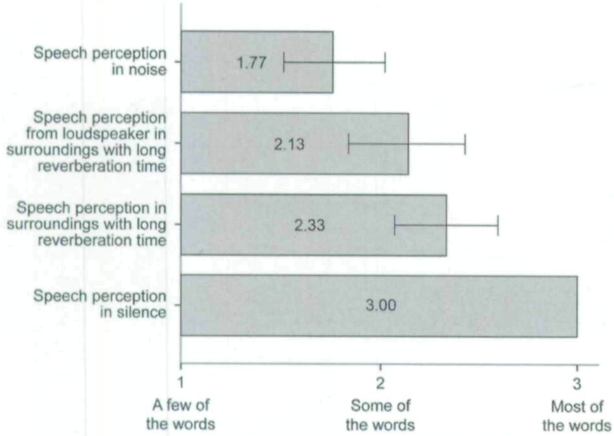

Fig 1. Self-reported speech perception in different acoustic surroundings. On speech perception scale from 1 to 3, score of 1 indicated that a few words were heard, score of 2 indicated that some words were heard, and score of 3 indicated that most words were heard. Error bars show 95% confidence intervals.

values to z-scores (Table 5). The reliability of the scales was tested with Cronbach's alpha. The scales were then used in an analysis of correlation. To explore variation among the participants, we tried out the key variables as dependent variables in simultaneous multiple linear regression analyses. Variables that did not significantly improve the model's explanatory power were removed. All statistical analyses were performed with SPSS version 16.0 (SPSS Inc, Chicago, Illinois).

RESULTS

Experience of Communication Handicaps. According to self-reported experience, 93% of those with permanent unilateral deafness (28 of 30) experienced the condition as a communication handicap that had a negative effect on their interactions with other people. Of those who reported a communication handicap, 36.7% reported a small effect, 43.3% some effect, and 13.3% a large effect (Table 2).

Areas of Communication Difficulty. Figure 1 shows self-reported speech perception in different acoustic surroundings: in silence, in noise, and in cases in which the speech issued from a loudspeaker and there was a long reverberation time. Communication was reported to be most disturbed in surroundings with background noise, as 37% of the participants reported hearing few of the words, 50% reported hearing some of the words, and 13% heard most of the words. For the perception of speech from loudspeakers in rooms with a long reverberation time, 23% of the participants reported hearing few of the words, 40% heard some of the words, and 37% heard most of the words (Table 4). Train stations, airports, churches, and gymnasiums were mentioned as examples of difficult places to hear speech. All of the participants stated, however, that unilateral deafness did not hinder their speech perception in a structured or one-to-one conversation in a silent setting, in which they reported hearing the most words spoken.

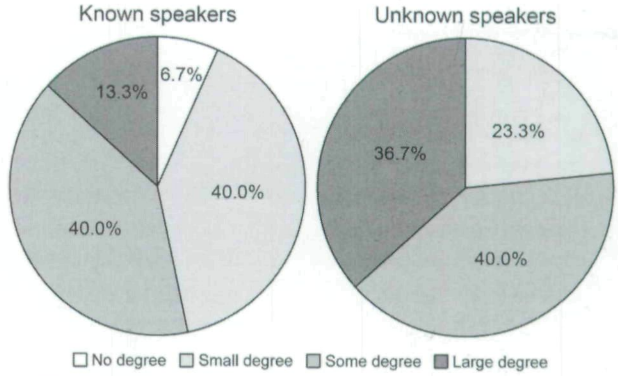

Fig 2. Self-reported experience of exclusion in conversation with speakers known or not known to 30 listeners.

The familiarity of the speakers was significant for the subjects' degree of participation in a conversation (Fig 2). In an unstructured conversation with 4 or 5 speakers in quiet surroundings, the individuals with unilateral deafness reported significantly greater participation rates in conversations with known versus unknown speakers ($Z = 3.58$; $p < 0.001$). Twenty-eight of 30 (90%) stated that they felt left out of the conversation when 4 or 5 familiar persons participated. All of the participants reported various levels of reduced participation in conversations when 4 or 5 unfamiliar persons participated.

Results from the interviews further indicated that unilateral deafness could be experienced as negatively affecting the participant's overall performance, participation, and feelings of well-being. Questions on participation, well-being, and performance were related to the participant's school and work situation (Table 2). Because of variation in participants' ages and age of acquired deafness, there were some missing values in these data. For this reason, the mean scores from questions about school and work were used when reporting the results. On a scale from 1 to 4, the participants' mean ratings of the negative influence of unilateral deafness were 1.85 on performance, 2.03 on participation, and 2.08 on well-being.

Use of Listening Strategies. Twelve of 30 participants (40%) used avoidance strategies, sometimes avoiding gatherings with friends in surroundings with considerable background noise (Table 2). Figure 3 shows the extent to which head-turning and speech-reading strategies were used. Nearly all of the participants (97%) reported that visual input, enhanced by the use of speech-reading, was important for speech perception in background noise. Twen-

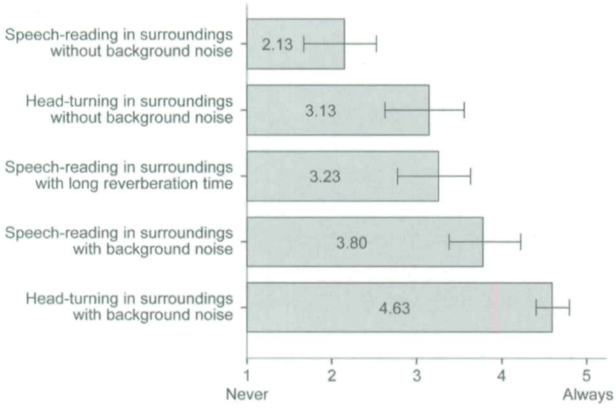

Fig 3. Self-reported degree of head-turning and looking strategies (speech-reading) used by 30 individuals with unilateral deafness in communication situations in different acoustic surroundings. On scale from 1 to 5, score of 1 indicated that strategy was not used, and score of 5 indicated that strategy was always used. Error bars show 95% confidence intervals.

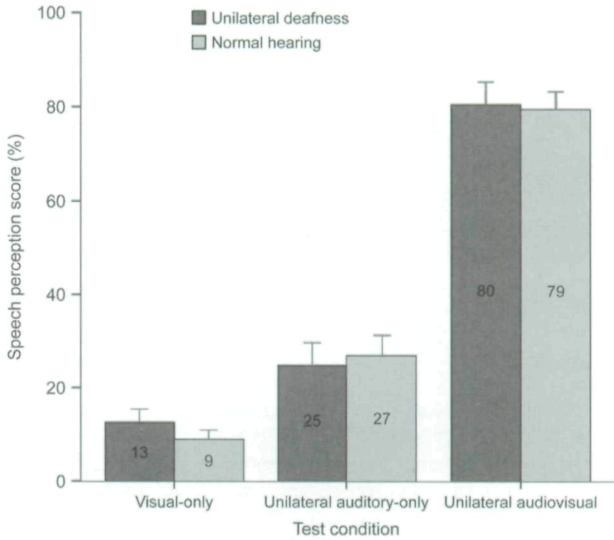

Fig 4. Unilateral speech perception of sentences in noise. Dark bars show percentage of correct scores attained by 30 individuals with unilateral deafness. Light bars show percentage of correct scores attained by 30 individuals with normal hearing in whom unilateral deafness had been temporarily induced. Error bars show 95% confidence intervals.

ty-one (70%) said they were completely dependent upon, or that they placed great importance on, seeing the person speaking. In surroundings with a long reverberation time, 27 of 30 subjects (90%) stated that speech-reading was important, and 19 of 30 subjects (63%) stated that visual input was important for speech perception, even in quiet surroundings. The results also revealed participants' extensive use of head-turning strategies. When communicating in surroundings with background noise, all participants reported that they turned the hearing ear toward the source of the sound to achieve better speech perception. In quiet surroundings, 25 (83%) reported that it was important to be placed strategically in relation to the source of the sound. Several persons in the sample described communicating while driving a car or meeting strangers on public transportation as examples of situations in which suboptimal head positioning could hinder speech perception.

Speech Perception Testing. The mean (±SD) speech perception score for the unilaterally deaf participants in noise under the audiovisual condition was 80.5% ± 16% (Fig 4). For the auditory-only condition, the mean score was 24.8% ± 16.3%, and for the visual-only condition, 12.5% ± 9.6%. There was a statistically significant improvement in mean speech perception scores when visual information was added to auditory information (unilateral auditory-only, 24.8% ± 16.3%; audiovisual, 80.5% ± 16%; $t(29) = -20.7$; $p < 0.001$).

Correlation and Cluster Analysis. The question about the degree of communication handicap subjects experienced was considered a key question and was kept as a single variable, labeled "communication handicap." The self-reported speech perception variable comprised the mean scores from 8 variables derived from the interview on speech perception in different acoustic surroundings (Table 4). Cronbach's alpha for this scale was calculated to be 0.607. The results from the cluster analysis of the remaining interview variables showed 4 clear clusters that accorded with the themes of the questions. These clusters were labeled as follows: exclusion, coping, speech-reading, and head-turning (Table 5). The communication handicap variable was moderately to strongly correlated with all of the clustered variables. The results indicate that a high degree of communication handicap was associated with poorer self-reported speech perception ($r = 0.424$), increased feelings of exclusion ($r = 0.481$), poorer coping ($r = 0.372$), and increased use of speech-reading ($r = 0.391$) and head-turning strategies ($r = 0.365$; Table 6).

There was no significant correlation between the degree of communication handicap experienced and the results of the tests for speech perception in noise (unilateral auditory-only, $p = 0.904$; unilateral audiovisual, $p = 0.222$; visual-only, $p = 0.994$). Of the demographic variables, only the variable for hearing aid fitting ($r = 0.367$; $p = 0.046$) was significantly correlated with communication handicap, indicating an association between higher degrees of communication handicap and a willingness to try out a hearing aid. Tests of unilateral auditory-only and unilateral audiovisual speech perception in noise showed significant negative correlations with age ($r = -0.432$ and $p = 0.017$, and $r = -0.376$ and $p = 0.040$, respectively). Unilateral audiovisual speech

TABLE 6. CORRELATION MATRIX SHOWING ASSOCIATIONS BETWEEN MAJOR VARIABLES (N = 30)

	Communication Handicap	*Self-Reported SP*	*Coping*	*Exclusion*	*Head-Turning*	*Speech-Reading*	*Audiovisual SP*	*Auditory-Only SP*
Self-reported SP	0.424*							
Coping	0.372*	0.227						
Exclusion	0.481†	0.273	0.544†					
Head-turning	0.365*	–0.032	0.202	0.209				
Speech-reading	0.391*	0.373*	0.331	0.328	–0.091			
Audiovisual SP	0.230	0.006	–0.237	–0.237	–0.193	0.027		
Auditory-only SP	0.023	–0.072	–0.031	–0.237	–0.178	0.244	0.583†	
Visual-only SP	–0.001	0.121	0.029	0.128	–0.022	0.35	0.264	0.235

*Correlation is significant at 0.05 level (2-tailed).

†Correlation is significant at 0.01 level (2-tailed).

perception also correlated significantly with participants' age at the onset of deafness (r = –0.410; p = 0.024). There was a strong significant correlation between the measured unilateral auditory-only speech perception in noise, and unilateral audiovisual speech perception in noise conditions (r = 0.583; p = 0.001).

In a simultaneous multiple regression analysis in which communication handicap was used as the dependent variable and the clustered, demographic, and speech perception variables were used as independent variables, only the variables for exclusion and self-reported speech perception were important, predicting 27% ($R^2 = 0.37$; adjusted $R^2 = 0.27$) of the variation. Increased feelings of exclusion (beta = 0.401; p = 0.024) and poorer self-reported speech perception (beta = 0.289; p = 0.096) could be associated with an increased feeling of possessing a communication handicap.

DISCUSSION

Data from both the interview and the speech perception test indicate that persons with unilateral deafness experience a significant disability in auditory function, affecting their speech perception, communication, and social interaction. The results support and substantiate earlier reports that define unilateral deafness as a significant disability.[1,3,5] The results from the present study also indicate that experiences of disability with this condition can vary, as 37% of participants deemed the problem of communicating with unilateral deafness to be of only minor importance.

The participants who experienced the communication situation as difficult most commonly reported difficulty with speech perception in background noise. They described having a problem segregating the voice (the signal) from the background noise. These results are in line with earlier studies that confirmed that unilateral listeners do not function as well as binaural listeners when they are in a competitive noisy environment.[17,18] Further, in the present study, those with unilateral deafness reported feeling excluded in conversations with multiple speakers, reduced well-being in social settings, and feeling it necessary to avoid social gatherings in which they thought significant background noise would be present. Our results do not corroborate the study by Colletti et al,[10] which found unilateral deafness to have no significant effect on social achievement. The consequences described by the participants confirm the handicapping condition of the hearing loss. Furthermore, their reactions can be compared to those often observed among persons with bilateral hearing loss.[19,20] In light of these findings, the failure to identify cases of unilateral deafness through newborn hearing screening may represent a significant clinical problem.[21] If neonatal screening for hearing loss defines the loss by the hearing level in the best ear, it would fail to register a child with unilateral deafness. In accordance with observations in the present study, it is important to identify unilateral deafness as soon as possible and give individuals with unilateral deafness information about their condition and about rehabilitation.

Unilaterally deaf participants made extensive use of strategies to increase hearing. Both listening strategies, such as head-turning, and visual strategies, such as speech-reading, were significant for speech perception in social interactions. In surroundings with background noise, all of the unilaterally deaf participants attempted to achieve direct listening by turning the hearing ear toward the speech signal. The need to find the ideal placement to make social interaction possible was described as stressful by the unilaterally deaf participants. We found a significant correlation between the increased use of speech-reading and increased speech perception; however, there was a stronger indication that the increased use of compensatory strategies was associated with an increased feeling of having a communication handicap. These findings support earlier reports of increased stress levels in individuals with unilateral deafness.[1]

The results from the speech perception in noise test in the present study underscore the significant effect of visual support on speech perception, which backs up numerous studies that have previously demonstrated that visual speech information is beneficial for comprehending speech and for speech perception in noise.[22] We found a 56% increase in word recognition from the auditory-only condition to the audiovisual condition. This difference could be very important for facilitating communication, and it should be taken into consideration when planning a unilaterally deaf person's rehabilitation, such as in classroom settings, in other learning situations, and in work situations. These findings are in line with those of earlier reports.[6,23-25]

The degree of communication handicap that participants experienced did not significantly correlate with the results of the tests for auditory-only or audiovisual speech perception in noise. This finding most likely indicates that the test we used to measure speech perception did not sufficiently measure unilateral speech perception in daily situations. This may be because in daily life, sound and speech frequently enter the ears from angles other than 0°. Additionally, earlier studies, such as that of Hallberg et al,[20] have concluded that the psychosocial consequences of hearing loss cannot be predicted from audiometric data alone. In concurrence with Hallberg at al,[20] we conclude that the psychosocial consequences of unilateral deafness, such as decreased feelings of well-being, poor coping, increased feelings of experiencing a handicap, and feelings of exclusion in social interactions cannot be predicted from the applied speech perception tests in noise. Our findings indicate, however, a closer association between the participants' self-reported speech perception and their experiences of the psychosocial consequences of unilateral deafness.

An interesting finding of the present study was that having more experience with unilateral deafness did not yield an advantage to participants with unilateral deafness under the applied test condition. We found no difference in unilateral speech perception test scores between the groups tested. The normal-hearing group, who were rendered temporarily unilaterally deaf, achieved speech perception scores similar to those of the group who had been unilaterally deaf for 3 to 67 years. The strategies reported in this study might seem to have a positive effect on speech perception, but such effects were not observed under the applied test condition, when speech and noise were entering the two ears from a 0° angle. This finding might indicate that for specific listening situations, long-standing experience with unilateral deafness yields no advantage over temporary deafness on one side. Our findings suggest a rehabilitative approach that takes into consideration how different listening environments can affect the communication situation for unilaterally deaf individuals. To further explore our findings, it would be interesting to explore the influence of intervention programs that develop targeted strategies for enhancing speech perception in noise.

Only 20% of the participants in the present study had been fitted with a hearing aid, and only 1 person used the hearing aid on an occasional basis. Participants' self-reported reasons for not using the CROS hearing aid were that there was too much set-noise from the aids and that the open plug in the normal-hearing ear covered up too much of the natural sound. This finding aligns with earlier studies indicating that the conventional CROS hearing aid system was successful in only 10% of patients with total deafness on one side and normal hearing on the other side.[12] Recent studies, however, have shown increased user satisfaction with a bone-anchored hearing aid.[26] At present, there is a rising interest in the use of cochlear implants in the rehabilitation of unilateral deafness. Vermeire and Van de Heyning[27] found significant improvement in speech understanding in noise and in the subjective self-assessment of hearing status after cochlear implantation in individuals with unilateral deafness and incapacitating tinnitus.

Some caveats to the current study are that the number of participants included in the study was small and that only a limited number of factors were studied. We chose an experimental setting with a given level of noise and a 0° signal-to-noise angle in order to generate the smallest advantage possible for binaural versus unilateral listeners; thus, the results might differ under conditions outside this experimental setting. Among the participants, 44% reported that having unilateral deafness was of minor or no significant importance to their communication situation. Further research, including a larger number of participants and more comprehensive observation of possible contributing factors, is warranted. The interview used was constructed for this study only. Thus, it would be helpful to further standardize the questionnaires and interviews to include a range of factors applicable to unilateral deafness.

CONCLUSIONS

The major finding in this present study was that persons with unilateral deafness experienced a significant disability in auditory function that affected their speech perception, communication, and social interaction. Second, the major areas of difficulty were communicating in background noise, in poor acoustic surroundings, and with limited access to speech-reading or direct listening. The feeling of exclusion in communication situations with multiple speakers was a common experience that could lead to the avoidance of social interaction. The third finding was that the communication handicap experienced by subjects was not associated with the results of a test for speech perception in noise. This finding might indicate that the test we used did not accurately simulate unilateral speech perception in daily life. Further, it is likely that other factors affecting individual coping strategies play a central role in the degree to which one considers unilateral deafness to be a communication handicap. Finally, we observed that under the applied test condition, the participants with long-standing unilateral deafness seemed to have no advantage over those who had come to the condition more recently, as they did not have better speech perception in noise than did the normal-hearing reference group who experienced temporary deafness on one side.

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