J Am Acad Audiol 7: 15–22 (1996)

Comparison of Performance with a Conventional and a Two-Channel Hearing Aid

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Abstract

Twenty experienced binaural hearing aid users evaluated a two-channel behind-the-ear instrument, with a low band that offered dynamic range compression and a high band that provided linear amplification. After a 5-week trial period, data from the Profile of Hearing Aid Performance (PHAP), the Speech Perception in Noise (SPIN) test, as well as 2-cm^3 coupler measurements were compared for the two-channel experimental device and the subjects' single-channel aids. Most subjects showed significant improvement on the SPIN test and on the PHAP with the two-channel aid. Subjective comments were predominantly enthusiastic, and 17 subjects (85%) chose to exchange their present instruments for the experimental aid. After a total of 19 weeks experience with the two-channel hearing aid, 15 subjects were re-evaluated; the mean scores for the SPIN test and for most of the PHAP subscales were unchanged from those observed at the 5-week assessment.

Key Words: Compression, hearing aids, multichannel, self-assessment

The advent of wearable multichannel hearing aids has enabled audiologists to manipulate electroacoustic parameters independently for different spectral regions, thus allowing greater flexibility in addressing the client's amplification requirements. Several researchers have reported significantly improved speech recognition in noise for two-channel (2-CH) compression hearing aids compared to either single-channel (1-CH) linear or compression devices (Villchur, 1973; Yanick, 1976; Laurence et al, 1983; Moore and Glasberg, 1986; Johnson et al, 1988; Benson et al, 1992; Gordon-Salant and Sherlock, 1992; Moore et al, 1992). On self-report questionnaires, experienced hearing aid users have also expressed subjective preference for a 2-CH compression aid over 1-CH instruments (Hall and Jacobs, 1991; Benson et al, 1992; Moore et al, 1992). Recently, Fabry and Stypulkowski (1993) reported that, in background noise, their subjects preferred a 2-CH configuration with compression in the low band and linear amplification in the high band. In quiet, however, linearity in the low band was preferred.

Today, most commercially available 2-CH instruments incorporate compression circuitry in both bands, with the various electroacoustic parameters programmable via a computer interface or other auxiliary hardware. One exception is Oticon Corporation's MultiFocus. This device is unique in that its low band, below 1600 Hz, provides dynamic range syllabic compression with continuously changing compression ratios based upon the level of the input signal with unity gain at very high levels; the high band, separated by a 24 dB/octave slope, uses linear amplification with symmetric electronic peak clipping. Three potentiometer controls allow for variation of the low-frequency gain, the high-frequency gain, and the high-frequency output. The algorithm that determines the compression and gain characteristics is based on average loudness growth data for sensorineurally impaired individuals. The behind-the-ear (BTE)

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configured instrument has no user-adjustable volume control (Brunved, 1994).[1]

The purpose of this study was to determine whether experienced hearing aid users would derive any objective or subjective advantage from the 2-CH MultiFocus hearing aid compared to their conventional 1-CH device.

METHOD

Subjects

Twenty male veterans between the ages of 49 and 82 (mean = 66.8 years) who had used BTE hearing aids on a full-time basis for at least 10 years volunteered to participate in the investigation. Since the experimental device was a BTE, only individuals who were currently using BTE hearing aids were considered for inclusion. It was felt that this would neutralize the extraneous cosmetic factor in any preference rating of the devices. In accordance with the manufacturer's suggested subject selection criteria, individuals with fluctuating losses, reverse slope audiograms, and conductive components were eliminated from consideration. All subjects had a moderate to severe sensorineural hearing loss (Fig. 1) and normal tympanograms, and had received new binaural instruments and appropriate earmolds from our facility within the past 4 to 18 months. Seventeen subjects had aids that provided linear amplification and three had output compression instruments.

In a comparative evaluation where subjects serve as their own controls, the subjects' own hearing aids form the baseline against which change in performance is measured. For this reason, every effort was made to ensure that these subjects were using high-quality hearing aids appropriately fitted by contemporary clinical standards. All aids had been selected from among those that met the Department of Veterans Affairs electroacoustic performance standards and were fitted using NAL-R targets (Byrne and Dillon, 1986). As is frequently the case with individuals in this hearing loss category (Byrne, 1987; Byrne and Cotton, 1988), the target gain requirements were generally met in the low-frequency range but often could not be met for the high frequencies. Postfitting adjustments of the electroacoustic parameters were implemented as needed to optimize the subjective benefit for these difficult-to-fit patients.

[1]Since the completion of this study, MultiFocus has become available in an in-the-ear (ITE) version.

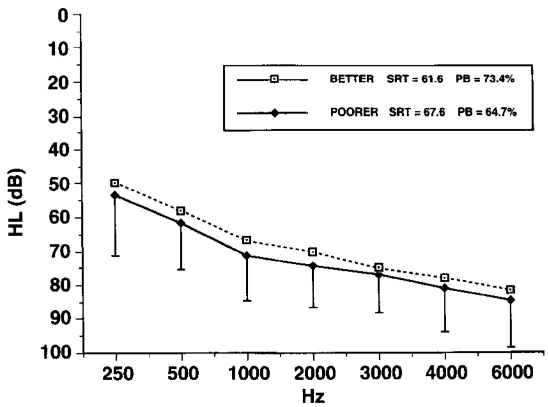

Figure 1 Mean audiogram for the better and poorer ears of all 20 subjects.

Procedures

Subjects participated in a minimum of three test sessions. On the initial visit, each subject had a complete audiologic evaluation, his communication performance with the 1-CH aid was assessed both subjectively and objectively, and electroacoustic measurements of the aid were obtained. The subject was then fitted with the 2-CH experimental instruments. On the second visit, 1 week later, the subjects were given the opportunity to report on their experience with the 2-CH aid, and modifications, when appropriate, were made to the settings of the aids. At the third visit, after 5 weeks, subjective, objective, and electroacoustic data were collected for the 2-CH aids, and the subjects were given the option of permanently exchanging their 1-CH aids for the 2-CH instruments. Fifteen subjects (75%) provided additional subjective and objective data after having used the 2-CH aids for approximately 5 months. A complete description of the specific test procedures is given below.

Speech Recognition. Objective performance was evaluated using Lists 1 and 5, counterbalanced among the subjects, of the revised Speech Perception in Noise (SPIN) test (Bilger et al, 1984). The recorded lists were played through a 2-CH cassette tape deck (Nakamichi, LX-3) and routed via a GSI-10 audiometer to a loudspeaker (JBL 4301B) positioned in a double-walled sound booth at 0° and approximately 1.5 metres from the subject. The second track of the tape containing the 12-talker babble was routed to a loudspeaker placed equidistant from the subject at 180°. The volume control of the aids was maintained at the setting that the subject had been using when he entered the test environment.

The SPIN sentences were initially presented at 63 dBA and the babble at 55 dBA (+8 SBR) measured at the location of the subject's head. This signal presentation level has been suggested by Cox and Alexander (1992) to reflect an everyday situation in which the environmental noise is low but speech cues are reduced because of low speech intensity and absent visual cues. Several practice sentences were administered and, if the subject did not respond correctly to two of three high-predictability (PH) stimuli, the signal level was increased in 5-dB steps or the SBR was enhanced in 2-dB increments. The test material ultimately was presented to nine subjects in the 63/55 dBA condition. Nine subjects required a 68 dBA signal and two a 73 dBA level; the SBR for these latter 11 subjects varied between +8 to +16 dB. The signal and babble levels established for each subject were employed for all subsequent administrations of the SPIN test.

Self-assessed Hearing Aid Performance. Subjects evaluated their communication performance by completing the Profile of Hearing Aid Performance (PHAP), a 66-item paper and pencil self-assessment inventory that requires the subject to estimate how frequently he is having difficulty in everyday communication situations. The areas probed by the PHAP are divided into seven subscales: Familiar Talkers (FT), Ease of Communication (EC), Reverberation (RV), Reduced Cues (RC), Background Noise (BN), Distortion of Sounds (DS), and Aversiveness of Sounds (AV). A detailed explanation can be found in Cox and Gilmore (1990). The PHAP has been shown to have good test–retest reliability (Cox and Gilmore, 1990; Nelson and Palmer, 1994) and was selected over the more commonly used Profile of Hearing Aid Benefit (PHAB). The latter test directly compares aided to unaided performance (Cox et al, 1991); however, it was felt that, in light of the severity of the hearing loss and the longstanding history of hearing aid use, for these subjects, self-assessment of unaided performance would be of questionable validity.

Electroacoustic Measurements. The 2-cm^3 coupler measurements of the gain and output were made using the composite noise signal of a Fonix 6500 hearing aid test system with rms input levels of 50, 70, and 90 dB SPL. The potentiometers and volume control of the 1-CH aids were at the subject's use setting. The potentiometer settings of the 2-CH aids were those used by the subjects during the evaluation period subsequent to the 1-week finetuning session.

2-CH Hearing Aid Fitting. The subjects were initially fitted with the 2-CH instruments by presetting the three potentiometer controls according to the manufacturer's fitting protocol. The low-frequency channel was adjusted according to the average audiometric threshold values at 250, 500, and 1000 Hz, the high-frequency channel according to the average threshold at 2000 and 4000 Hz (Brunved, 1994). The subjects were counseled about the potential differences that they may notice between the experimental aids and their own aids, particularly in relation to the absence of the volume control. They were instructed to keep a detailed diary of their listening experiences, paying particular attention to the following points: voice quality, ability to detect sounds not heard before, music, telephone performance, and understanding in group situations.

After a minimum of 7 days (mean = 14), the subjects returned for a finetuning of the aids based on their subjective experience, as recommended by the manufacturer and the findings of Punch et al (1994), who concluded that the "hearing aid fitting may be optimized by use of preference data that are acquired in the user's actual listening environment." Thirty-two of the 40 instruments (80%) required modification of at least one potentiometer setting. The subjects had a mean total of 35.5 days (range = 21–68 days) of experience when the second test session was completed. At this time, PHAP, SPIN, and 2-cm^3 coupler data were collected for the 2-CH aids, and subjects were given the option of exchanging their 1-CH aids for the MultiFocus.

RESULTS AND DISCUSSION

Speech Recognition

The group mean performance on the SPIN test for the 1-CH and 2-CH aids is shown in Figure 2. Data for each individual subject on all of the tests can be found in Table 1. SPIN percent correct data were transformed into rationalized arcsin units (rau) for all statistical analyses; however, for the range of scores obtained, the rau scores correspond closely to the percentage scores (Studebaker, 1985). Clearly, there was a substantial improvement for both the low- (PL) and high-predictability (PH) stimuli when using the 2-CH hearing aid (PL: mean difference = 21.74 rau, range = 0 to 62 rau, $t = 5.93$, $p < .0001$; PH: mean difference = 19.71 rau, range = –12.6 to 59.8 rau, $t = 4.76$, $p < .0001$). Nineteen of the 20 subjects (95%) demonstrated an improvement for word recognition for the PL stimuli

Table 1 Individual Data for Audiometric Threshold, PHAP, SPIN, and 2-cc Coupler Gain Measurements

	Frequency (kHz)				PHAP‡							SPIN‡		2-cc Gain (kHz)§			
														1-CH		2-CH	
Subject	0.5	1	2	4	FT	EC	RV	RC	BN	DS	AV	PL	PH	0.5	4	0.5	4
1*	35	50	70	75	12.3	24.7	40.1	33.1	47.5	14.7	42.8	20	52	−7	19	22	36
	50	65	75	80	10.7	8.9	24.9	37.6	25.6	10.8	13.8	32	84	−9	19	11	35
					7.3	15.9	33.2	38.8	27.9	23.2	42.8	24	68	−14	18	−1	18
2*	65	75	80	95	30.3	41.0	85.6	71.8	73.1	52.0	59.3	4	76	32	45	30	48
	65	80	95	85	17.6	30.3	69.2	55.2	59.3	33.3	38.5	52	76	33	45	18	46
					19.4	35.6	66.4	58.1	58.4	25.0	28.0	40	84	28	35	1	25
3*	50	55	70	95	19.4	53.4	61.0	45.7	67.8	67.4	73.6	12	80	28	42	27	43
	55	65	75	100	12.6	35.6	62.4	56.8	74.6	54.2	65.6	52	88	31	41	15	41
					17.6	48.1	63.8	47.1	65.5	72.7	83.8	48	12	10	29	2	23
4*	60	85	90	105	26.6	41.0	95.0	54.1	67.8	76.5	7.2	8	24	21	35	39	57
	60	90	90	105	8.9	14.1	50.0	35.8	25.8	10.2	1.9	16	76	24	34	23	50
					7.3	16.3	53.1	40.4	21.7	14.8	10.1	12	52	12	31	10	26
5*	60	70	65	75	26.7	53.4	72.1	76.0	87.0	37.2	53.0	32	96	45	52	38	41
	60	65	65	75	15.7	13.9	30.6	33.1	20.9	17.2	7.4	60	100	45	52	27	42
					12.0	13.9	24.8	24.8	22.4	8.7	6.7	60	100	32	34	11	25
6†	70	60	70	80	37.5	67.7	83.0	63.4	76.9	43.7	30.1	32	80	40	37	30	33
	75	75	70	75	12.63	21.1	38.8	38.8	39.8	53.8	4.7	52	80	42	39	18	31
														32	36	5	13
7*	55	60	70	65	35.7	78.4	81.4	69.0	83.9	81.0	65.1	28	60	24	27	32	37
	75	70	65	60	21.3	67.7	67.8	33.6	75.3	74.8	70.5	36	68	23	27	24	34
					21.3	80.1	59.6	54.0	65.4	72.8	79.9	28	88	14	22	7	17
8*	60	65	85	100	67.7	67.7	92.2	80.0	97.5	72.3	1.9	36	56	4	35	30	42
	65	75	80	85	9.6	14.7	70.5	24.9	60.0	12.7	5.6	60	92	8	34	21	43
					14.6	7.6	60.9	22.9	83.8	12.0	67.5	56	96	3	25	2	26
9*	60	60	60	70	32.0	53.1	85.4	68.9	78.6	6.8	1.0	44	72	12	35	26	33
	60	65	65	70	14.6	7.6	69.2	42.7	57.5	6.5	3.8	60	88	11	34	18	30
					22.9	22.9	69.0	39.8	62.1	3.2	1.0	72	96	−1	27	8	8
10	75	75	75	85	11.0	40.9	63.4	64.9	71.6	18.7	35.4	8	44	44	42	38	52
	90	85	85	85	10.4	23.3	65.7	58.1	56.8	41.7	32.1	28	84	43	40	24	45
														31	32	11	24
11*	35	50	55	65	8.9	8.9	22.7	23.1	36.5	8.7	35.4	32	96	13	33	12	25
	25	45	60	70	7.3	18.0	29.6	22.1	30.4	7.6	56.1	40	88	13	34	7	25
					4.1	35.4	23.2	15.3	28.1	8.7	37.8	16	84	−4	16	−1	11
12*	65	80	85	75	74.7	71.1	99.0	91.0	98.2	72.0	75.5	12	36	18	36	42	53
	75	85	90	90	28.6	37.4	77.2	52.7	65.4	47.5	26.2	24	80	17	36	31	49
					42.9	51.7	90.9	77.4	90.7	70.5	59.8	28	72	10	21	13	26
13†	50	50	50	55	19.6	28.4	31.8	49.9	54.4	2.8	32.4	56	68	22	20	20	27
	50	50	50	60	4.1	12.7	32.0	36.0	17.2	9.2	24.2	60	96	22	20	12	27
														5	6	1	17
14*	55	70	65	65	10.4	19.4	66.3	33.0	54.5	29.0	46.8	44	88	25	32	20	25
	55	75	65	75	8.9	7.3	26.1	23.2	20.7	25.0	17.1	80	92	25	33	13	25
					2.6	36.9	20.8	27.8	34.2	31.3	46.8	60	92	20	30	3	15
15*	40	55	60	75	18.0	17.7	56.8	42.9	53.1	34.2	15.9	20	84	−1	14	19	30
	30	45	65	85	2.6	8.3	27.8	17.9	22.2	8.3	22.3	52	96	0	14	11	30
					16.4	10.4	20.1	10.8	18.9	12.0	26.0	32	92	0	14	0	15
16*	65	70	75	70	37.4	40.9	85.6	56.8	64.6	52.0	55.1	48	80	18	33	32	35
	70	75	80	80	12.0	24.7	76.1	59.6	49.9	27.2	46.6	48	80	20	34	21	36
					12.3	8.9	31.1	33.0	29.0	25.0	21.6	40	72	1	20	6	26
17	75	80	70	70	23.1	40.9	63.4	70.2	58.9	57.0	69.3	28	64	29	31	38	39
	80	85	75	70	5.7	2.6	17.8	37.2	22.5	39.7	27.3	36	76	31	31	28	38
														23	27	12	23
18†	55	65	60	80	11.0	65.6	78.6	80.1	70.6	60.2	58.8	32	64	23	36	27	39
	70	75	65	75	17.4	31.7	65.0	69.1	65.4	37.2	35.3	48	88	23	35	14	38
														17	25	4	22
19*	75	85	90	85	48.0	71.1	96.3	81.4	90.7	52.0	60.2	0	40	20	25	32	44
	75	85	100	100	7.6	17.7	51.7	37.4	53.9	18.7	26.8	48	96	21	23	23	40
					48.0	42.7	88.3	67.8	86.3	39.5	55.9	76	96	21	25	11	21
20*	75	80	70	65	17.7	39.0	52.6	46.6	49.1	22.7	26.0	16	88	34	37	37	42
	60	90	90	105	4.1	10.4	16.4	22.4	21.1	14.2	9.4	64	100	37	38	27	43
					12.0	23.1	29.0	34.6	31.1	25.0	9.8	64	100	30	31	10	26

*Included in 19 week follow-up.
†Opted not to take the 2-CH hearing aid.
‡First row = 1-CH, second row = 2-CH at 5 weeks, third row = 2-CH at 19 weeks.
§First row = 50 dB, second row = 70 dB, third row = 90 dB.
FT = familiar talkers, EC = ease of communication, RV = reverberation, RC = reduced cues, BN = background noise, DS = distortion of sounds, AV = aversiveness of sounds, PL = low predictability, PH = high predictability.

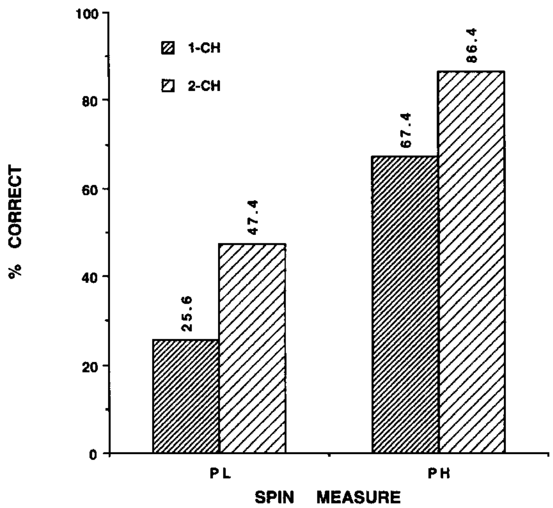

Figure 2 Mean SPIN scores with the 1-CH and 2-CH hearing aids (N = 20) PL = low predictability; PH = high predictability.

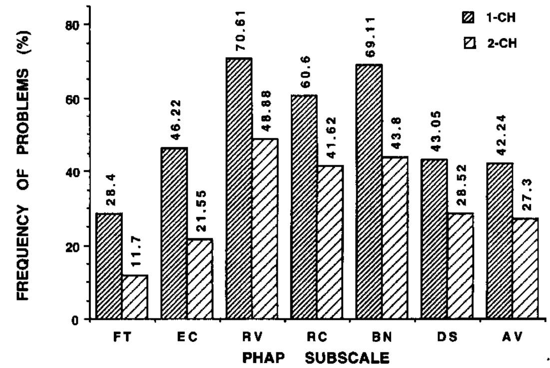

Figure 3 Mean PHAP scores for the 1-CH and 2-CH hearing aids (N = 20).

and 16 of the 20 (80%) for the PH stimuli. There was a low but significant correlation between the scores with the 1-CH and the 2-CH aids for both the PL and PH sentences (r = .46 and r = .44, respectively, $p_{.05} = .38$ for one-tail test).

The speech recognition data were compared for the nine subjects who received the SPIN stimuli at 63 dB SPL and the 11 subjects for whom a higher presentation level was required. The subjects who required the higher presentation level had, for the most part, more severe hearing loss and obtained lower scores on both SPIN measures. The pattern of improvement with the 2-CH aids, however, was similar for the two groups.

Self-assessment

The mean PHAP scores for the 1-CH and 2-CH hearing aids are displayed in Figure 3. The frequency of self-assessed communication difficulty was significantly less with the 2-CH aid on all seven PHAP subscales (t-statistics ranged from 3.18 to 6.97, $p_{.05} = 2.09$). After an average of 5 weeks with the 2-CH aid, 15 subjects showed improvement of 25 percent or more on at least one of the subscales, while 10 subjects had this magnitude of change on three or more measures. Based on the test–retest data of Cox and Gilmore (1990) and Nelson and Palmer (1994), a change of 25 percent exceeds the 90 percent critical difference for all of the PHAP subscales and would suggest a true difference between the two hearing aids. Table 2 displays the correlations (r) between the PHAP scores with the 1-CH aid and the 2-CH aid; in other words, the extent to which the initial 1-CH self-assessment would predict the subjective improvement derived from using the 2-CH instrument. These Pearson r values, though modest, are significant and are on the same order of magnitude as those reported by Cox and Rivera (1992), who used the unaided PHAB scores to predict the benefit of amplification.

A correlation coefficient (r) was computed between the difference in speech recognition scores obtained with the two aids and the difference in self-assessed frequency of problems with the two aids. No apparent relationship was found between improved word recognition ability on the SPIN test and the self-assessed benefit of the 2-CH aid as reflected in the change in scores on relevant PHAP subscales (for BN vs PL, r = .01; BN vs PH, r = .30; for RC vs PL, r = .25, RC vs PH, r = .38). Cox and Alexander (1992) reported a similarly poor correlation between objective and subjective benefit measures.

Figure 4 displays the mean 2-cm^3 coupler composite noise output data for the 1-CH and the

Table 2 Correlation Coeffecients (r) Between Self-assessed Performance on the PHAP with the 1-CH and 2-CH Aids

PHAP Subscale	*r*
FT	.52*
EC	.57*
RV	.70*
RC	.45†
BN	.64*
DS	.53*
AV	.65*

*p < .01, † p < .05, (one-tail).
FT = familiar talkers, EC = ease of communication, RV = reverberation, RC = reduced cues, BN = background noise, DS = distortion of sounds, AV = aversiveness of sounds.

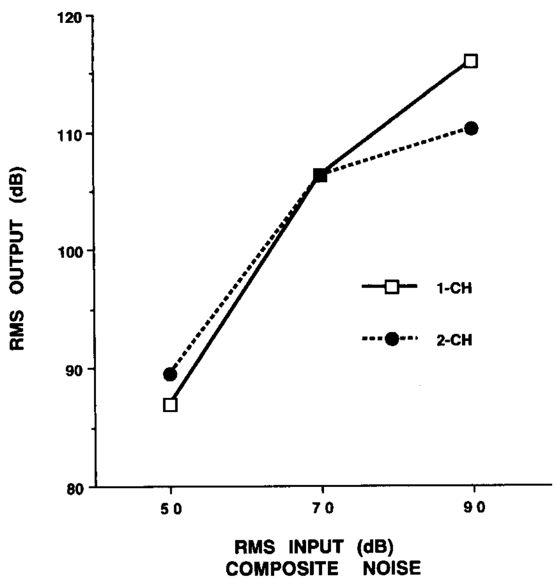

Figure 4 Mean 2-cm³ coupler composite noise output for the 1-CH and 2-CH hearing aids with inputs of 50, 70, and 90 dB SPL.

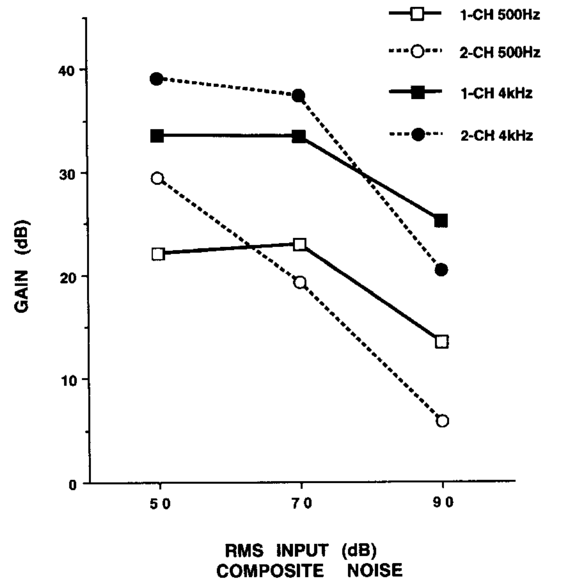

Figure 5 Mean 2-cm³ coupler gain values for the 1-CH and 2-CH hearing aids at 500 and 4000 Hz with inputs of 50, 70, and 90 dB SPL.

2-CH hearing aids. The mean rms output of the two instruments did not differ when the input signal was 50 dB or 70 dB; however, the output of the 2-CH aid was significantly lower ($t = 3.49$, $p < .01$) when the input was 90 dB, reflecting the aid's compression circuitry.

A comparison of the mean gain values for the 1-CH and 2-CH aids seen in Figure 5 found the 2-CH aid to have greater gain at 500 Hz and 4000 Hz ($t = 2.57$ and 2.24, respectively, $p < .05$) when the rms input was 50 dB. With a 90-dB input signal, on the other hand, the 2-CH aid showed significantly less gain at both frequencies ($t = 3.24$ at 500 Hz and $t = 2.96$ at 4000 Hz, $p < .01$). There was no significant difference in gain between the two aids for either frequency when the input was 70 dB. Analysis of the average 500- to 4000-Hz slope at the 70-dB input level, the intensity that most closely approximated the SPIN presentation level, revealed a significant difference ($t = 3.59$, $p < .01$) between the two aids. The slope of the 1-CH aid was 10.57 dB (SD = 9.60), while that of the 2-CH aid was 18.0 dB (SD = 5.51). It is interesting to note that, based on the average audiogram for the better ear and average real-ear to coupler corrections for BTE aids, the NAL-R prescriptive formula calls for 15-dB greater coupler gain at 4000 Hz than at 500 Hz. The 1-CH aid provided sufficient gain in the high-frequency region to meet this requirement for only five subjects, while the 2-CH aid achieved the slope target for 15 subjects. The speech recognition data for the five subjects whose 1-CH aids met the NAL-R slope at 70 dB did not differ from the rest of the group; however, this subsample is too small to suggest any conclusion about the significance of meeting the NAL-R targets.

Subjective Comments

The subjective comments about the 2-CH aid were predominantly enthusiastic, with surprisingly few complaints over the absence of a volume control. Table 3 presents data from the 16 subjects who maintained the "listening diary." All but the last item required a yes or no response. Seventeen subjects (85%) opted to keep the MultiFocus in place of their original hearing aids. Upon questioning, many of these subjects reported that their motivation for choosing the MultiFocus was predicated on factors besides their improved speech recognition ability. They cited the increased clarity of music and of their own voice and, in particular, its superiority in picking up previously undetectable sounds. Apparently, the wide dynamic range compression in the low-frequency channel made soft sounds audible, and this was perceived as a significant benefit for these severely impaired users. The SPIN and PHAP data for the three subjects who preferred to keep their own aids were indistinguishable from the rest of the group. One individual could not tolerate an aid without a volume control; another had a minimal, low-frequency conductive component

Table 3 Subjective Comments from "Listening Diary" after 5 Weeks Experience with the 2-CH Hearing Aids

Voice quality is satisfactory	16
Able to detect sounds not heard before	12
Quality of music is satisfactory	14
T-coil is effective	8
Understanding in a group is satisfactory	12
Rating of 2-CH aid on a scale of 1–10	
Mean	8.1
SD	1.2
Range	5–10

N = 16

and preferred the power of his linear device; finally, the third admitted to preferring the sound quality of the 2–CH aid but was willing to wait until it became available as an ITE.

Long-term Follow-up

Figure 6 displays the mean SPIN scores for the 15 veterans who chose the 2-CH aids and were re-evaluated after a total of 19.5 weeks (range = 17–22 weeks) of experience with the device. No difference was found between the mean SPIN scores at 5 weeks and at 19 weeks for this long-term follow-up subgroup (PL, t = .85; PH, t = .15). The PL and PH scores on both occasions were significantly higher than with the 1-CH instrument (PL: 5 week, t = 4.92, 19 week, t = 3.19; PH: 5 week, t = 3.73, 19 week, t = 3.84; $p_{.01}$ = 2.98). The amount of improvement measured after 19 weeks, relative to the SPIN scores obtained with the 1-CH aid, correlated highly with the improvement measured at 5 weeks (PL, r = .90; PH, r = .84).

Since performance was not assessed until the subjects had 5 weeks of experience with the 2-CH device, it cannot be determined whether the difference between the 1-CH aid and the 2-CH aid would have been evident at the outset. The recent speech recognition data of Gatehouse (1992, 1993) raise the possibility that the advantage of the 2-CH aid may have actually increased with time as the subjects became "acclimatized" to its electroacoustic characteristics. In the present study, however, any acclimatization would have to have occurred within the first 5 weeks since there was no difference in the SPIN data between 5 and 19 weeks.

It can be seen in Figure 7 that the PHAP scores at 19 weeks for all of the subscales that deal with the understanding of speech (FT, EC, RV, RC, and BN) were still lower, indicating fewer problems with the 2-CH aids than with the 1-CH aids

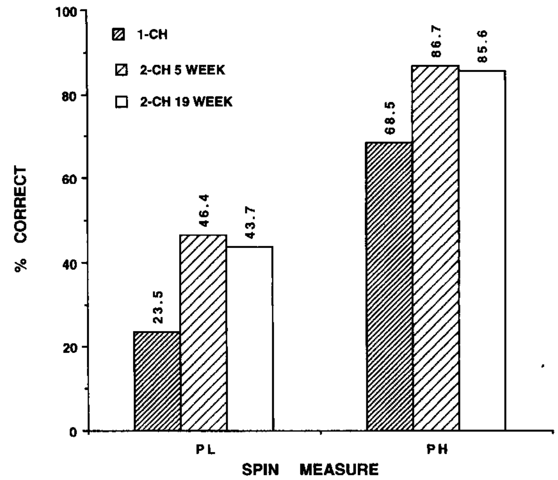

Figure 6 Mean SPIN scores for the 1-CH hearing aids and the 2-CH hearing aids after 5 and 19 weeks experience (N = 15).

(t-statistic ranged from 2.74 to 4.95, $p_{.05}$ = 2.15). There was a trend, reaching significance ($p < .05$) only for the EC and DS subscales, for the subjects to report more problems at 19 weeks than at 5 weeks. Since there was no commensurate tendency observed for the speech recognition data, the increase in self-assessed difficulty may indicate that, initially, the subjects assessed their performance with the 2-CH aids very favorably in comparison with their prior experience with the 1-CH hearing aids; by 19 weeks, however, they may be more cognizant of the limitations of the 2-CH aids relative to "normal" functioning. Cox and Alexander (1992), on the other hand, using the PHAB with a group of mild to moderately impaired subjects, reported an increase in subjective benefit between the second and tenth week of hearing aid use for all of the speech-related subscales; however, the differences in the

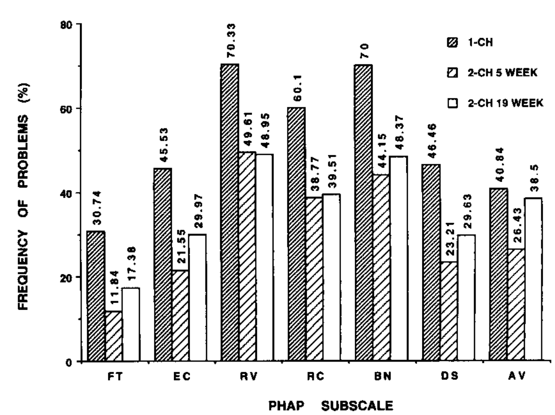

Figure 7 Mean PHAP scores for the 1-CH hearing aids and the 2-CH hearing aids after 5 and 19 weeks experience (N = 15).

assessment tool, the time frame employed, and the degree of hearing loss may account for the discrepancies between the two studies.

In summary, the 2-CH hearing aid evaluated in this study produced a significant increase in word recognition scores and a significant reduction in the self-assessed frequency of communication difficulty for a group of highly motivated and experienced BTE hearing aid users with moderate to severe sensorineural hearing loss. It remains to be determined whether these results can be explained solely by the manufacturer's compression algorithm, the fact that there are two isolated channels, or some other electroacoustic features. The objective and subjective measures of hearing aid benefit that were apparent after 5 weeks of experience with the experimental device showed no change upon re-evaluation at 19 weeks. The lack of correlation between the objective and subjective measures may be due to the fact that the objective data were gathered at only one input level. Finally, it must be emphasized that these findings may not be generalizable to individuals whose severity and configuration of hearing loss and resulting loudness growth function differ appreciably from the subjects employed in the present investigation.

Acknowledgment. Portions of this study were presented as a poster paper at the annual meeting of the American Academy of Audiology, April 1994, Richmond, VA.

The opinions contained herein are the private views of the authors and are not to be construed as the official policy or position of the Department of Veterans Affairs.

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