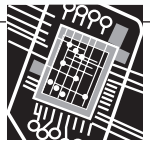
The Binaural Advantage: Evidence From Subjective Benefit & Customer Satisfaction Data

By Sergei Kochkin, PhD, &
Francis Kuk, PhD

Five samples of subjects (n=3,951) with bilateral hearing loss were analyzed to determine if there were significant end-user differences in perception of satisfaction and subjective benefit between subjects fit monaurally (n=944) and subjects fit binaurally (n=3,007). All five samples showed strong "directionality" effect in favor of binaural fittings, enhanced enjoyment in outdoor environments and improved benefit (as measured by APHAB). High performance hearing instruments demonstrated a stronger binaural advantage in sound quality and in multiple listening situations.



In 1983, the Hearing Industries Assn.[1] conducted the first major study of the hearing-impaired market. This study documented that the binaural hearing instrument fitting penetration rate of the U.S. market was only 22%. The figure was considered low by industry leaders at this time since the majority of hearing instrument users have a bilateral hearing loss. Given the known benefits of binaural hearing instruments, a concerted effort was made by the industry to encourage the use of binaural hearing instruments. In a 10-year period, the binaural penetration of the entire hearing instrument market has risen to 52% due to the increasing incidence of binaural hearing instrument fitting in the United States over this same time frame (24.5% in 1984 to 65.3% in 1994).[2]

This remarkable growth can be attributed to the paradigm shift in the mid-80s that "two hearing aids are better than one" and to the many excellent papers written by clinicians and researchers on the benefits of binaural hearing instrument fittings.[3,4] Conceivably, this growth is also attributed to a more enjoyable hearing instrument wearing experience on the part of the consumer.

Recently, the series of reports on adult onset auditory deprivation from monaural hearing instrument use has contributed significantly to the selection of binaural hearing instruments by professionals.[5–13] In addition to their apparent value, these deprivation studies lay the physiological basis for potential litigations[14] if consumers are not given the proper rehabilitative option.

It is gratifying to see the increase in binaural hearing instrument fittings. After all, it has been demonstrated in clinical and laboratory studies that binaural hearing instrument wearers may benefit from the ability of the central auditory system to integrate binaural information and enjoy benefits such as binaural loudness summation[15], masking level difference[16], localization[17], and elimination of head-shadow.[18] The combination of these psychoacoustic benefits means that binaural hearing instruments could yield speech that is "clearer," "more comfortable" and "more natural." In addition, the wearer may be able to locate a sound source more readily even at a low intensity level. More consistent speech understanding, regardless of its source, and better speech understanding in noise may also be possible with binaural fitting (over monaural). By and large, these benefits have been reported consistently in clinical and laboratory studies.[19–30]

Consumer surveys also supported the results of laboratory studies on the benefits of binaural amplification. Several studies[31,32,33] have reported that over 75% of binaural hearing instrument wearers continued to wear binaural hearing instruments at their follow-up evaluation (minimal three months post-fitting). Other surveys, using different subject populations, revealed that binaural hearing instrument preference was not affected by subject experience with hearing instruments[21,25,26,34], hearing loss symmetry[35], and cost of hearing aids.[26,33] In addition, these studies all reported improvement in speech clarity as the most frequent advantage of binaural amplification. Stereophonic hearing, balanced

Sergei Kochkin, PhD, is director of market development and market research at Knowles Electronics, Inc., and Francis Kuk, PhD, is director of audiology at Widex Hearing Aid Co.

hearing and better overall hearing were also reported frequently.

While most of these surveys confirmed the laboratory findings on binaural advantages over monaural fittings, they consistently showed minimal binaural advantage over a monaural hearing instrument in noisy situations (even though such benefit can be demonstrated in the clinic). Furthermore, the magnitude of the binaural benefit also varied from one survey to another.

Minor variation in experimental results is a normal outcome of cross-centers studies. For example, the competence of the investigators/dispensers fitting the hearing instruments; the choice of different brands/models of hearing instruments at each site; the characteristics of the patient population being sampled (e.g., paying vs. non-paying, gender, age, previous hearing instrument history, etc.) could all lead to different outcomes. While all these studies contributed greatly to the acceptance of binaural hearing instruments in their own right, a more "generic" study is necessary to determine the average consumer satisfaction for binaural hearing instruments fit by the average dispenser.

The discrepancy in outcome between laboratory studies and real-world reports of binaural advantage in noise suggests that the test conditions used in the laboratories may not reflect the same listening conditions that wearers encountered in their daily lives. For example, the typical intensity level that was used in most laboratory studies was about 65 dB SPL. In real-life, depending on the level of the background noise, speech could easily be increased to 75 dB SPL.[36] In addition, the speech spectrum will also be shifted to a higher frequency.

These changes in test conditions may have a significant impact on the functioning of the hearing instruments. In the laboratory, where testing is conducted at the conversational level, the output of the hearing instruments may not be high enough to reach saturation. Thus, binaural hearing instrument wearers may fully enjoy the binaural benefits, including better speech understanding in noise. In real-life noisy situations, the speech and noise levels may be so high that they saturate the hearing instruments, leading to distortion products and the masking of any benefits provided by the binaural fitting. Under this hypothesis, a hearing instrument wearer would prefer binaural hearing instruments if the aids produce no or minimal distortion in noise. Otherwise, a monaural hearing instrument would be preferred instead.

Naidoo and Hawkins[29] tested this hypothesis by comparing the preference of 15 hearing-impaired subjects for binaural/monaural amplification. Subjects wore a variety of hearing instrument circuits and listened to discourse passages presented in quiet and in noise backgrounds of 70 dB SPL and 80 dB SPL noise. The circuits that were compared included the K-Amp, Class

				Non-programmable					
Technology	**MarkeTrak (III & IV)**			**ASP (BILL)**			**Wide dynamic range compression (TILL)**		
	Monaural	**Binaural**	**Difference**	**Monaural**	**Binaural**	**Difference**	**Monaural**	**Binaural**	**Difference**
Sample size	*289*	*835*		*63*	*142*		*126*	*425*	
Overall satisfaction									
Hearing aid	3.68	3.71	0.03	3.77	3.77	0.00	3.61	3.82	0.21 *
Dispenser service	4.30	4.33	0.03	4.56	4.46	-0.10	3.44	3.56	0.12
Average hours worn per day	10.10	10.20	0.10	9.89	10.32	0.43	10.10	11.10	1.00 *
Product Features									
Fit/comfort	4.06	4.09	0.03	4.12	4.11	-0.01	4.06	4.00	-0.06
Ease/volume adjustment	4.00	3.87	-0.13 *	4.08	4.03	-0.05	3.79	3.63	-0.16
Visibility	3.87	3.84	-0.03	3.68	3.57	-0.11	3.95	4.09	0.14
Frequency of Cleaning	3.70	3.73	0.03	3.94	3.92	-0.02	3.86	3.77	-0.09
Warranty	3.81	3.71	-0.10	3.85	3.99	0.14	3.82	3.82	0.00
Ease/Battery Change	4.30	4.20	-0.10 *	4.28	4.26	-0.02	4.32	4.20	-0.12
On-Going Expense	3.43	3.37	-0.06	3.53	3.43	-0.10	3.71	3.52	-0.19 *
Performance/Value Factors									
Battery Life	3.69	3.50	-0.19 **	3.09	3.32	0.23	3.60	3.50	-0.10
Improves My Hearing	3.96	4.01	0.05	3.82	3.97	0.15	3.87	3.98	0.11
Reliability	3.96	3.90	-0.06	3.98	3.90	-0.08	3.91	3.86	-0.05
Clearness Tone/Sound	3.67	3.64	-0.03	3.49	3.63	0.14	3.54	3.64	0.10
Natural Sounding	3.52	3.52	0.00	3.55	3.54	-0.01	3.56	3.59	0.03
Value (Price vs. Performance)	3.52	3.48	-0.04	3.47	3.45	-0.02	3.42	3.44	0.02
Directionality	3.27	3.57	0.30 **	3.17	3.54	0.37 **	3.30	3.56	0.26 **
Whistling/Feedback/Buzzing	3.23	3.12	-0.11	3.09	3.33	0.24	3.35	3.35	0.00
Use In Noisy Situations	2.87	2.85	-0.02	2.53	2.90	0.37 **	2.66	2.81	0.15
Listening Environments									
One-On-One	4.31	4.30	-0.01	4.18	4.37	0.19 *	4.09	4.28	0.19 **
T.V.	3.74	3.80	0.06	3.83	3.82	-0.01	3.71	3.79	0.08
Small Groups	3.66	3.66	0.00	3.58	3.80	0.22	3.46	3.76	0.30 ***
Place of worship	3.41	3.55	0.14 *	3.65	3.60	-0.05	3.46	3.63	0.17
Outdoors	3.51	3.57	0.06	3.33	3.54	0.21	3.46	3.67	0.21 *
Car	3.43	3.48	0.05	3.27	3.40	0.13	3.22	3.47	0.25 *
Restaurant	3.22	3.25	0.03	3.13	3.31	0.18	3.03	3.23	0.20 **
Concert/Movie	3.21	3.26	0.05	3.29	3.36	0.07	3.26	3.28	0.02
Telephone	2.94	2.99	0.05	3.02	3.12	0.10	3.26	3.32	0.06
Large Group	2.74	2.77	0.03	2.52	2.86	0.34 **	2.62	2.81	0.19
Subjective Benefit (APHAB) (AVG : EC/BN/RV)									
Total benefit	23.90	29.90	6.00 *	21.60	27.80	6.20	19.30	26.00	6.70 *
Total unaided	63.50	65.40	1.90	61.20	61.20	0.00	56.20	59.50	3.30

*p<.05, **p<.01, ***p<.001, ****p<.0001

Table 1. *Mean ratings of satisfaction and benefit for bilateral loss subjects fit monaurally and binaurally.*

D, linear output compression, Manhattan II and a linear peak-clipping circuit. The results showed that subjects preferred binaural amplification for all but the linear peak-clipping circuit. The authors speculated that such preference was related to the level of distortion products generated at high input levels. All but the linear peak-clipping circuits generated minimal distortion at high input levels. *Subjects preferred the linear peak-clipping circuit in the monaural mode over the binaural mode because there was less distortion with one hearing instrument. The other circuits were preferred in the binaural mode because the reduced distortion allowed subjects to enjoy the binaural advantages.*

The results of Naidoo and Hawkins[29] study have significant implications for the reconciliation of the noted difference in binaural benefits in noise between real-world and laboratory findings. Hearing instruments fitted up to the late-'80s or early-'90s were mostly linear hearing instruments with peak-clipping as a method to limit output. It is likely that these hearing instruments would saturate in noisy situations when worn outside the clinic. The high distortion products may have masked the binaural advantage in noise, leading to no noticeable superiority for binaural instruments over monaural instruments.

In the past 10 years, advances in hearing instrument technology have led to the development of many high quality, high performance circuits. For example, many programmable hearing instruments offer compression as either a limiting mechanism (i.e., compression limiting) or as a signal processing method (e.g., wide dynamic range compression). These circuits, along with other non-programmable nonlinear hearing instruments (e.g., K-amp), minimize distortion at high input levels. It is conceivable that, if the consumer surveys were conducted today, binaural hearing instrument wearers using these high performance hearing instruments would report a binaural advantage (over a monaural fitting) even in the presence of noise.

Programmable						
Multiple channel & multiple memory			Multiple channel & single memory			Average
Monaural	Binaural	Difference	Monaural	Binaural	Difference	Difference
258	*1033*		*208*	*572*		4 samples
4.04	4.10	0.06	3.83	3.94	0.11	0.10
4.59	4.64	0.05	4.58	4.47	-0.11	-0.01
11.70	12.20	0.50	12.10	12.50	0.40	0.58
4.17	4.13	-0.04	4.03	4.10	0.07	-0.01
3.82	3.76	-0.06	3.51	3.59	0.08	-0.05
3.83	3.79	-0.04	3.70	3.81	0.11	0.02
3.88	3.86	-0.02	3.85	3.86	0.01	-0.03
3.91	3.83	-0.08	3.82	3.82	0.00	0.01
4.38	4.26	-0.12 **	4.28	4.28	0.00	-0.07
3.58	3.60	0.02	3.62	3.61	-0.01	-0.07
3.65	3.42	-0.23 ***	3.65	3.60	-0.05	-0.04
4.15	4.26	0.11 *	4.08	4.20	0.12	0.12
4.09	4.11	0.02	3.90	4.02	0.12	0.00
3.80	3.95	0.15 **	3.68	3.83	0.15 *	0.14
3.81	3.84	0.03	3.66	3.75	0.09	0.03
3.58	3.64	0.06	3.51	3.54	0.03	0.02
3.37	3.68	0.31 ****	3.18	3.56	0.38 ****	0.33
3.67	3.66	-0.01	3.61	3.62	0.01	0.06
2.99	3.03	0.04	2.87	2.90	0.03	0.15
4.35	4.44	0.09 *	4.26	4.40	0.14 *	0.15
3.67	3.83	0.16 *	3.65	3.73	0.08	0.08
3.79	3.88	0.09	3.56	3.74	0.18 *	0.20
3.53	3.58	0.05	3.31	3.53	0.22	0.10
3.63	3.77	0.14 *	3.42	3.75	0.33 ****	0.22
3.40	3.51	0.11	3.34	3.47	0.13	0.16
3.15	3.12	-0.03	3.00	3.10	0.10	0.11
3.25	3.31	0.06	2.96	3.18	0.22 **	0.09
3.12	3.10	-0.02	3.13	3.03	-0.10	0.01
2.75	2.79	0.04	2.51	2.70	0.19 *	0.19
24.50	31.20	6.70 ****	23.90	30.60	6.70 **	6.58
61.00	65.40	4.40 ***	66.50	67.70	1.20	2.22

The latest consumer survey on binaural hearing instrument satisfaction/preference was conducted over a decade ago. In view of the potential impact made by our recent understanding of adult-onset auditory deprivation, advances in hearing instrument technology and the increased incidence of binaural hearing instrument fitting, it is time that the profession re-examine the current status of binaural hearing instrument benefit. This information, in addition to its academic value, should also be helpful for third party payers to evaluate the efficacy of binaural hearing instruments over a monaural hearing instrument.

Consequently, the purpose of the present study is to measure average consumer satisfaction for binaural hearing instruments using a "generic" approach. That is, satisfaction for all brands/models of hearing instruments, fit by dispensers of all levels of competence, to consumers with different degrees of hearing loss and expectations for hearing instruments will be sampled. Specifically, the following research questions are asked:

1 Given the increasing incidence of binaural hearing instrument fittings over the last ten years, do consumers "experience" the binaural advantage; in other words, is the binaural advantage reflected in differences between subjects fit monaurally and binaurally?

2 Given the improvement in hearing instrument technology in the past 10 years, is there a difference in satisfaction for binaural hearing instruments between wearers of conventional hearing instruments and wearers of high performance hearing instruments?

Methodology

▶ *Survey Method*: We queried the Knowles customer satisfaction databases for subjects with bilateral hearing loss who were fit either monaurally or binaurally. The development of these databases has been described in previous studies.[37,38,39]

Five samples of subjects were identified as having adequate sample sizes for comparison (e.g., monaural versus binaural). The Knowles MarkeTrak sample, which reports on consumer satisfaction with the "average" hearing instrument sold in the United States, consists of hearing instruments less than two years of age purchased between 1993-1994 (MarkeTrak IV) or 1990-1991 (MarkeTrak III). The majority of the instruments were non-linear with peak clipping. In addition, four "high-performance" products were compared based on recent research conducted by this author.[38] Two samples were non-programmable and they employed either wide-dynamic range compression or ASP/BILL (base

increase at low level) signal processing. Two samples were multiple channel programmable instruments. They were further divided into single and multiple memory products. Our databases did not have enough subjects with single channel programmable product.

▶ *Instrumentation:* Both the Knowles MarkeTrak Satisfaction Survey[30] and the Abbreviated Profile of Hearing Aid Benefit (APHAB)[40] were administered by mail to each subject in this study. With respect to satisfaction, 34 items were measured using a 5-point Likert scale (very satisfied, satisfied, neutral (defined as equally satisfied and dissatisfied), dissatisfied and very dissatisfied). The 34 items were broken down as follows: overall index (1), hearing instrument product features (8), performance and value (9), performance in specific listening situations (10), and dispenser service (6). In addition, five behavioral measures were captured (hours worn per day, impact on quality of life, likelihood of repurchasing hearing instrument brand, repurchasing from dispenser, and in recommending hearing instruments to friends).

The APHAB consists of 24 items scored on four 6-item subscales: Ease of Communication (EC), Background Noise (BN), Reverberation (RV) and aversiveness of Sounds (AV). The respondents completed the APHAB under both aided and unaided conditions in the same administration by indicating the percent of time they experienced problems hearing under the situations described in the inventory. A person's score on each subscale is the mean rating of the six items making up the subscales. An APHAB subscale was scored only if the respondent answered four or more items within the specific subscale. Scores range from 1-99% for all subscales. In addition, total APHAB scores were computed by taking the mean of subscales EC, BN and RV. The rationale for combining these subscales was based on the results of a factor analysis of the total unaided subscale scores.

Results

Table 1 summarizes the mean satisfaction ratings for subjects fit monaurally and binaurally. Mean differences are also reported and are followed by asterisks (*) if the difference is statistically significant. With respect to the average hearing instrument data (MarkeTrak III & IV), binaural fittings had a significant positive impact on ability to localize sounds (e.g., directionality including higher ratings in "place of worship") and the total APHAB score. However, subjects who wore binaural hearing instruments were more likely to give lower (i.e., less satisfactory) ratings to ease of volume adjustment, ease of battery change and battery life.

With respect to the high performance hearing instruments, all four samples had significantly higher ratings on directionality and subjective benefit. The ASP/BILL sample rated higher on performance in noisy situations in addition to two listening situations. The WDRC rated higher on overall satisfaction and five additional listening situations. The multiple channel/multiple memory product rated higher on perceptions of improved hearing, clearness of sound and three listening situations. The multiple channel/single memory sample rated higher on clearness of sound and five listening situations. All four products demonstrated higher mean differences in outdoor environments (three were significant). One out of the four products were rated significantly lower on ease of changing the battery and battery life (multiple channel/multiple memory), while the WDRC product was rated lower on-going expense.

The average monaural-binaural difference of the high performance product is documented in the last column in Table 1 and graphically portrayed in Fig. 1. In this figure, the relative advantage of binaural fittings is expressed as a percentage of the most notable binaural factor (i.e., directionality). The Fig. 1 profile demonstrates that enhanced localization due to binaural fittings also results in enhanced listening enjoyment in outdoor and difficult listening situations such as small and large groups. Logically, binaural fittings also result in lower satisfaction ratings on expense and in adjustment of the instrument (volume controls and battery change).

The satisfaction ratings for directionality as a function of technology are presented in Fig. 2. The satisfaction score differences (i.e., binaural minus monaural) ranged from a low of 8% points (WDRC) to a high of 19% points (multiple channel/single memory). The average change in satisfaction across all four technologies was 14.5% points compared to 13% points for the average hearing instrument (MarkeTrak).

Conclusions

Hearing instruments that were fit up to the late-'80s or early-'90s were still mostly linear hearing instruments with peak-clipping as a method to limit output (i.e., MarkeTrak sample). It is likely that these hearing instruments would saturate in noisy situations when worn outside the clinic. Because of the high distortion they produced, it is likely that any binaural advantage in noise may have been masked, resulting in little or no noticeable superiority with binaural fittings in difficult listening situations. To a certain extent the MarkeTrak data support this hypothesis. High ratings in directionality and subjective benefit were noticed with binaural fittings, but little else in terms of listening enjoyment in difficult situations.

In the past 10 years, advances in hearing instrument technology have led to the development of many high quality, high performance circuits. For example, many programmable hearing instruments offer compression as either a limiting mechanism (i.e., compression limiting) or as a signal processing method (e.g., wide dynamic range compression). These circuits, along with other non-programmable, nonlinear hearing instruments (e.g., K-amp), minimize distortion at high input levels.

Naidoo and Hawkins[29] demonstrated that such technological differences could lead to a difference in preference for binaural hearing instruments in a laboratory situation. This study corroborates their findings. High performance hearing instruments can preserve some of the noted advantages of binaural fittings in more difficult listening situations. It was our belief that binaural hearing instrument wearers using these high performance hearing instruments would report a binaural advantage (over monaural fitting) in more difficult listening situations.

While the findings are not consistent across all four high performance products, one can conclude that, in addition to enhanced localization and subjective benefit, high performance hearing instruments fit binaurally can be expected to enhance subjective perceptions of sound quality (clearness of tone/sound) and enjoyment in outdoor environments, one-on-one communication and traditionally more difficult listening situations (e.g., small groups, large groups and cars) over monaural fittings. ◆

References

1. Hearing Industries Assn.: *HIA Market Survey: A Summary of Findings and Business Implications for the U.S. Hearing Aid Industry*. Washington, DC: HIA, 1984.
2. Kochkin S: MarkeTrak IV: 10-year trends in the hearing aid market—Has anything changed? *Hear Jour* 1996; 49 (1): 23-34.
3. Libby ER: *Binaural Hearing and Amplification: Vol. 1 & 2*. Chicago, IL: Zenetron, Inc., 1980.
4. Markides A: *Binaural Hearing Aids*. New York, NY: Academic Press, 1977.
5. Burkey JM & Arkis PN: Word recognition changes after monaural and binaural amplification. *Hear Instrum* 1993; 44 (1): 8-9.
6. Gatehouse S: Apparent auditory deprivation effects of late onset: The role of presentation level. *J Acoust Soc of Am* 1989; 86 (6): 2103-2106.
7. Gelfand S, Silman S & Ross L: Long term effects of monaural, binaural and no amplification on subjects with bilateral hearing loss. *Scand Aud* 1987; 16: 201-207.
8. Hood JD: Problems in central binaural integration in hearing loss cases. *Hear Instrum* 1990; 41 (4): 7-11, 56.
9. Silman S, Gelfand S & Silverman C: Late onset auditory deprivation: Effect of monaural versus binaural hearing aids. *J Acoust Soc of Am* 1984; 76 (5): 1357-1362.

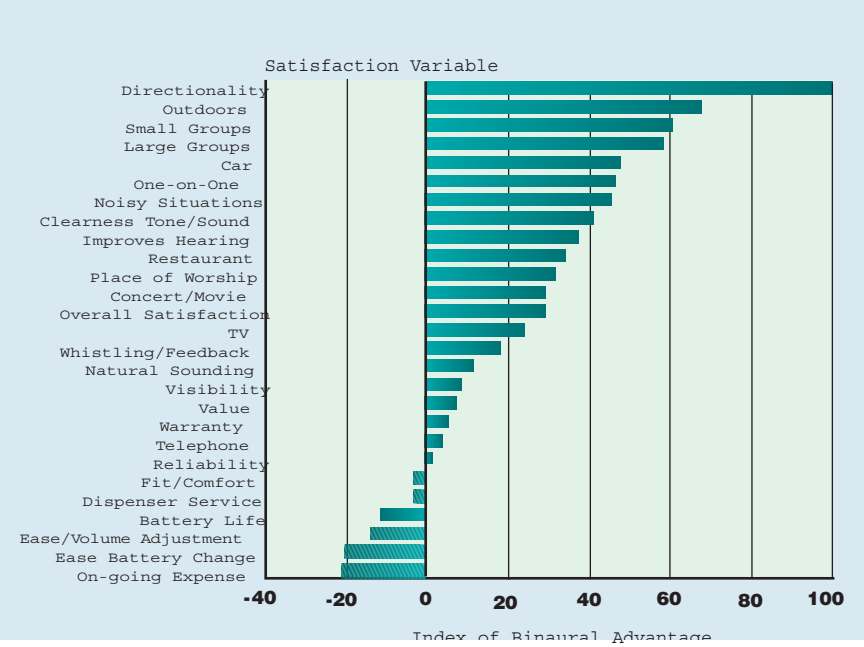


Fig. 1. *Relative impact of binaural hearing instruments on customer satisfaction of bilateral loss subjects.*

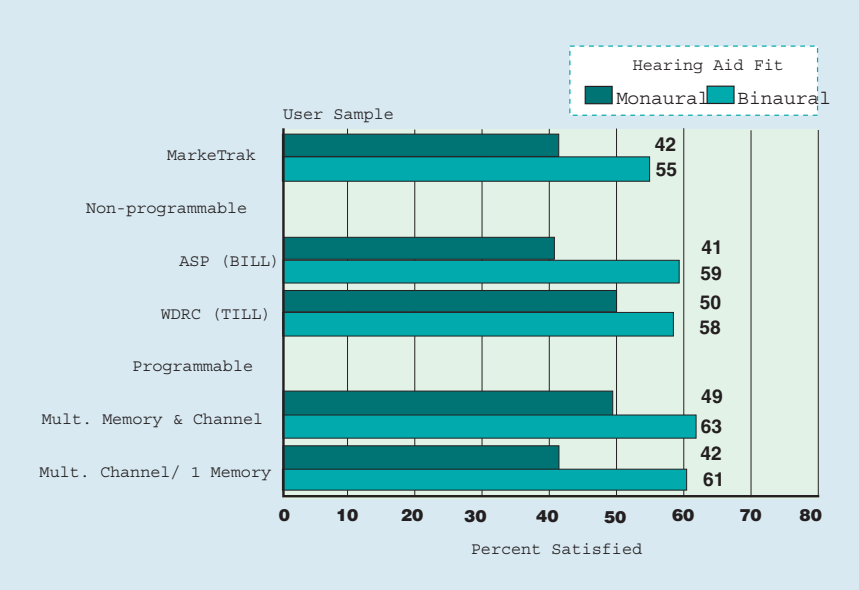


Fig. 2. *Satisfaction with directionality of hearing instrument for five samples of bilateral hearing loss subjects fit either monaurally or binaurally.*

10. Silman S, Silverman CA, Emmer M & Gelfand SA: Adult-onset auditory deprivation. *JAAA* 1992; 3: 390-396.
11. Silverman C: Auditory deprivation. *Hear Instrum* 1989; 40 (9): 26-30, 54.
12. Silverman C & Silman S: Apparent auditory deprivation from monaural amplification and recovery with binaural amplification: two case studies. *JAAA* 1990; 1: 175-180.
13. Stubblefield J & Nye C: Aided and unaided time-related differences in word discrimination. *Hear Instrum* 1989; 40 (9): 38-43.
14. Lowe G: Are audiologists guilty of malpractice if they do not recommend binaural amplification? *ASHA* 1988; 30 (11): 39-40.
15. Reynolds G & Stevens S: Binaural summation of loudness. *J of Acoust Soc of Am* 1951; 32: 1337-1344.
16. Licklidder JCR: The influence of interaural phase relations upon the masking of speech by white noise. *J Acoust Soc of Am* 1948; 20: 150-159.
17. Kock WE: Binaural localization and masking. *J Acoust Soc of Am* 1950; 22 (6): 801-804.
18. Sivian LJ & White SD: On minimum audible sound field. *J Acoust Soc of Am* 1933; 4: 233-321.
19. Balfour PB & Hawkins DB: A comparison of sound quality judgements for monaural and binaural hearing aid processed stimuli. *Ear and Hear* 1992; 13 (5): 331-339.
20. Belzile M & Markle D: A clinical comparison of monaural and binaural hearing aids worn by patients with conductive or perceptive deafness. *Laryngoscope* 1959; 69: 1317-1323.
21. Byrne D: Binaural hearing aid fitting: research findings and clinical application. In ER Libby's (ed.) *Binaural Hearing and Amplification: Vol. 2*. Chicago, IL: Zenetron, Inc., 1980: 1-21.
22. Byrne D, Noble W & Lepage B: Effects of long-term bilateral and unilateral fitting of different hearing aid types. *JAAA* 1992; 3: 369-382.
23. Durlach NI & Colburn S: Binaural phenomena. In CE Carterette & MP Friedman's (eds.) *Handbook of Perception*. New York: Academic Press, 1978: 364-466.
24. Durlach NI, Thompson CL & Colburn HS: Binaural interaction in impaired listeners—a review of past research. *Audiology* 1981; 20: 181-211.
25. Erdman SA & Sedge RK: Subjective comparisons of binaural versus monaural amplification. *Ear and Hear* 1981; 2:225-229.
26. Erdman SA & Sedge RK: Preferences for binaural amplification. *Hear Jour* 1986; 39 (11): 33-36.
27. Feuerstein J: Monaural versus binaural hearing: ease of listening, word recognition, and attentional effort. *Ear and Hear* 1992;
28. Grossman J: The binaural advantage for speech in noise. In ER Libby's (ed.) *Binaural Hearing and Amplification, Vol. 1*. Chicago, IL: Zenetron, Inc., 1980: 169-190.
29. Naidoo S & Hawkins D: Monaural/binaural preferences: Effect of hearing aid circuit on speech and sound quality. Poster session presented at the Am Acad of Aud (AAA) Annual Convention, Richmond, VA, 1994. (In press, 1997.)
30. Zurek P: Binaural advantages and directional effects of speech intelligibility. In GA Studebaker and I Hochberg's (eds.) *Acoustical Factors Affecting Hearing Aid Performance*. Second edition. Allen and Bacon, 1993: 255-276.
31. Jordan O, Creisen O & Bentzen O: Treatment with binaural hearing aids. Otolaryngology 1967; 85: 102-112.
32. Brooks DN & Bulmer D: Survey of binaural hearing aid users. *Ear and Hear* 1981; 2 (5): 220-224.
33. Briskey RJ & Cole P: Consumer evaluation of binaural hearing aids. *Hear Jour* 1983; 36 (3): 29-31.
34. Dirks D & Carhart R: A survey of reactions from users of binaural and monaural hearing aids. *J Speech Hear Dis* 1962; 27 (4): 311-322.
35. Chung SM & Stephens SDG: Factors influencing binaural hearing aid use. *Brit J Aud* 1986; 20: 129-140.
36. Pearsons K, Bennett R & Fidell S: *Speech Levels in Various Noise Environments*. Bolt, Beranek and Newman, Inc. EPA-600/1-77-025, 1977.
37. Kochkin S: MarkeTrak III identifies key factors in determining customer satisfaction. *Hear Jour* 1993; 46 (8): 39-44.
38. Kochkin S: Customer satisfaction and subjective benefit with high-performance hearing aids. *Hearing Review* 1996; 3 (12): 16-26.
39. Kochkin S: Subjective measures of satisfaction and benefit: establishing norms. Presented at the Am Acad of Aud Annual Convention, Dallas, TX, March 31, 1995. Also in *Seminars in Hear* 1997; 18 (1): 37-48.
40. Cox RM & Alexander GC: The abbreviated profile of hearing aid benefit (APHAB). *Ear and Hear* 1995; 16: 176-186.

Correspondence can be addressed to HR *or Sergei Kochkin, PhD, Knowles Electronics, Inc., 1151 Maplewood Dr., Itasca, IL 60143.*