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Articulation Index and Hearing Handicap

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Abstract

This investigation examined the relationship between perceived hearing handicap and the Articulation Index (AI) and the extent to which this relationship was influenced by the variables age, gender, degree of hearing loss, and audiometric slope. Subject age, gender, pure-tone thresholds, and scores for the Self-Assessment of Communication (SAC) and the Significant Other Assessment of Communication (SOAC) were extracted retrospectively from 373 patient files (194 males, 179 females). Correlation analysis revealed a significant ($p < .01$) negative relationship between AI values and both measures of hearing handicap, and also indicated that SAC/SOAC total scores correlated significantly ($p < .01$) with each other. Partial correlation analyses revealed that degree of hearing loss was the only variable under study that had substantial influence on the strength of AI/hearing handicap correlations.

Key Words: Articulation Index, hearing handicap

Abbreviations: AI = Articulation Index, SAC = Self-Assessment of Communication, SOAC = Significant Other Assessment of Communication

There is a growing consensus among audiologists that assessment of hearing loss not only requires measures of auditory function, but also estimates of hearing handicap (Schow and Nerbonne, 1982; Alpiner and Schow, 1993; McCarthy, 1994). This realization stems from evidence that measures of hearing impairment and hearing handicap are not correlated precisely and probably assess different aspects of auditory function (Schow and Nerbonne, 1982; Giolas, 1990; Schow and Gatehouse, 1990; Katz and White, 1997). These contentions are readily illustrated if one considers that two individuals with identically severe hearing losses, one congenital and the other acquired as an adult, will likely have vastly different communicative skills. Yet, professionals are pressed to define, quantify, or even predict accurately the influence that different levels of communicative function have on the effective and successful use of intervention strategies such as amplification. Stated differently, the role that an intervention strategy like amplification plays in the life of a hearing-impaired individual not only depends upon the extent and magnitude of sensory and neurologic inadequacies (i.e., hearing loss and communicative function) but also psychological parameters, experiential background, communicative capability, emotional adjustment, cognitive ability, social patterns, age, and motivation, among other variables.

The most common approach used by audiologists to predict communication function has been to assess word recognition performance. Although a variety of clinical word recognition assessment paradigms exist, the conceptual approach has been to select stimuli that represent some facet of everyday communication and to present these stimuli at intensity levels consistent with everyday listening. Unfortunately, there is growing concern over the use of word recognition assessment in clinical settings (Stach et al, 1995; Wiley et al, 1995; Stach, 1998). Of special concern has been the use of word recognition measures to select amplification since application of individual word recognition lists, applied across a variety of listening conditions, has been shown to be unreliable for rank ordering among amplification systems with similar electroacoustic performance (Walden et al, 1983). Moreover,

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repeated presentations of word recognition materials necessary to quantify communication function in a variety of common listening environments is too time consuming for efficient clinical applications.

Theoretically, the Articulation Index (AI) relates to word recognition performance since both are measures of speech intelligibility. For example, Studebaker and Sherbecoe (1993) noted that the AI can be used to predict speech intelligibility in the absence of data obtained by direct listener assessment. The AI has been advocated for counseling (Mueller and Killion, 1990; Humes, 1991; Kruger and Kruger, 1994), predicting speech intelligibility (Rankovic, 1991; Studebaker and Sherbecoe, 1993; Bentler, 1994; Pavlovic, 1994), selecting amplification systems (Pavlovic, 1988; Rankovic, 1991; Mueller, 1992; Studebaker, 1992; Studebaker and Sherbecoe, 1993; Kruger and Kruger, 1994), differentiating between sensory and neural auditory lesions (Gates and Popelka, 1992), and predicting speech understanding of individuals listening with personal hearing protection devices (Wilde and Humes, 1990). Although numerous AIs exist, each has in common the quantification of the amount of audible speech, coded as a ratio from 0.0 to 1.0, available to the listener (Killion et al, 1993). A score of 1.0 indicates that all of the speech spectrum is audible to the listener, a score of 0.5 means that one half of the total energy in the speech signal is audible, and the minimum AI of 0.0 indicates that the entire speech spectrum is inaudible. Thus, when applied to the hearing-impaired population, the AI score represents the percentage of the total acoustic information available in a specified speech sample (i.e., audible) as the result of hearing loss. The reader is referred to Humes (1991) or Pavlovic (1991) for tutorial overviews of the AI.

Hearing handicap scales represent another technique frequently used by audiologists to quantify the effects of hearing loss (Schow and Nerbonne, 1982; Schow and Gatehouse, 1990; Katz and White, 1997; Schow et al, 1993; McCarthy, 1994). Unlike the AI, rather than deriving predictions of communicative ability from audiometric data, hearing handicap scales provide information regarding the communication, social, emotional, and vocational difficulties caused by hearing loss, especially as perceived by the hearing-impaired individual. Data derived from hearing handicap scales have been used clinically to establish and assess rehabilitative needs, as part of history gathering, to evaluate rehabilitation success, screen for hearing loss, and validate compensation (Schow and Nerbonne, 1982; Ventry and Weinstein, 1982; Giolas, 1990; Schow and Gatehouse, 1990; ASHA, 1992; Alpiner and Schow, 1993). Among the more commonly used scales are the Hearing Handicap Inventory for the Elderly (Ventry and Weinstein, 1982), the Abbreviated Profile of Hearing Aid Benefit (Cox and Alexander, 1995), and the Self-Assessment of Communication (Schow and Nerbonne, 1982).

Although both AI and hearing handicap scales are enjoying increased clinical popularity (McCarthy, 1994, 1998; Stelmachowicz et al, 1994), only limited data are available that compare AI values to self-perceived hearing handicap scales. Whereas Hug et al (1996) failed to establish a significant relationship between improved AI values and self-perceived hearing handicap scores as a consequence of using amplification, Taylor and Kraus (1998) found a significant negative correlation between the AI and hearing handicap scores. Data from both of these investigations, however, were based on relatively small sample sizes, making it difficult to generalize confidently their findings to clinical applications.

The purpose of the present investigation was to examine the relationship between the AI values computed via the method advocated by Humes (1991) and perceived hearing handicap scores derived from the Self-Assessment of Communication (SAC) and the Significant Other Assessment of Communication (SOAC) (Schow and Nerbonne, 1982). The extent to which these relationships were influenced by the variables age, gender, degree of hearing loss, and audiometric slope also was assessed.

METHOD

Subjects

Data were collected from the files of 373 patients (179 females, 194 males) who were seen at the Central Michigan University (CMU) Hearing Clinic from 1992 to 1996. Each subject met the following criteria: between 18 and 85 years of age, either normal hearing sensitivity or an acquired sensorineural hearing loss with no threshold exceeding 100 dB HL for the octave range 250 through 4000 Hz, normal tympanometric functions, and a completed SAC. Although not an inclusion criterion, the SOAC had been completed for 292 of the 373 subjects. Approximately 95 percent of the subjects had bilaterally symmetric hearing loss. Table 1 presents the

Table 1 Demographic and Audiometric Data for the Experimental Sample

	Number	*Mean*	*SD*	*Range*
Age	373	55.0	18.5	18–85
Hearing loss*	373	29.9	18.3	-3.3–78.3
Slope†	373	22.2	21.9	-40–80
AI	373	0.66	0.29	0.00–0.99
SAC	373	25.5	9.8	10–50
SOAC	292	26.6	10.6	10–50

*Best binaural average for 1000, 2000, and 4000 Hz.
†Best threshold at 4000 Hz minus best threshold at 1000 Hz.

basic demographic, audiometric, and hearing handicap data for the patient population. Degree of hearing loss was defined for this investigation as the patient's best binaural pure-tone average for 1000, 2000, and 4000 Hz. Likewise, audiometric slope was defined as the decibel difference between the best threshold for either ear at 4000 Hz minus the best threshold for either ear at 1000 Hz. AI values were calculated following the procedures advocated by Humes (1991), except that pure-tone data represented the best threshold, regardless of ear, for octaves 250 through 4000 Hz.

Procedures

All client files for individuals seen at the CMU Hearing Clinic from January 1992 through 1996 were reviewed manually to determine if they met the inclusion criteria. Each file meeting the criteria was included as part of the experimental population. All relevant data (gender, age, pure-tone thresholds, and SAC/SOAC scores) were extracted from each file of the experimental population and recorded on data sheets in a manner that ensured subject confidentiality. The Humes (1991) method used to compute AI values has been shown to produce comparable AIs relative to other AI computational methods (Humes and Riker, 1992). The SAC and SOAC scales (Appendix) were selected as measures of hearing handicap because their reliability and validity are well documented (Schow and Nerbonne, 1982; Schow et al, 1983; Schow, 1995). Moreover, these scales have been endorsed for clinical use by the American Speech-Language-Hearing Association (ASHA, 1992). The SAC and SOAC scales were scored, analyzed, and interpreted based on raw data (Schow et al, 1990).

Pearson product-moment correlations were used to determine the statistical relationships between AI and SAC and SOAC scores, and partial correlations were used to establish the statistical relationship between the AI and SAC/SOAC, with age, gender, hearing loss, and audiometric slope controlled as individual and combination variables. Spearman rank correlations were used to examine the relationship between each individual SAC and SOAC item and AI scores.

RESULTS

Table 1 provides basic demographic and audiometric information for the subject sample. Recall that this investigation defined degree of hearing loss as the patient's best binaural pure-tone average for octaves 1000, 2000, and 4000 Hz, and audiometric slope was defined as the decibel difference between the best threshold for either ear at 4000 Hz minus the best threshold for either ear at 1000 Hz. Based on these definitions, the subject population presented an approximate 80-dB range of hearing impairment, and, although both positively and negatively sloped audiometric configurations were noted, the average audiometric slope was 22.2 dB, with the higher frequencies (2000–4000 Hz) most affected (see Table 1). AI values for the experimental population ranged from 0.00 to 0.99 (mean = 0.66; SD = 0.29), which indicated that the majority of subjects experienced a substantial reduction in speech audibility. The SAC and SOAC total raw scores ranged from 10 to 50 with similar means (SAC = 25.5; SOAC = 26.6) and standard deviations (SAC = 9.8; SOAC = 10.6) (see Table 1). The mean SAC and SOAC data predict that the subject population, as a group, demonstrated a slight hearing handicap (Schow et al, 1990).

Table 2 presents a matrix of the Pearson product-moment correlations between AI and SAC and SOAC total raw scores. As can be seen, significant ($p < .01$) overall negative correlations were found between AI values and each handicap scale. This inverse relationship generally supports the assumption that hearing handicap increases as speech information becomes less audible. The significant ($p < .01$) positive correlation found between the SAC and SOAC was expected based on similar findings from prior research (Schow, 1995).

Table 3 contains the partial correlations between the AI and SAC or SOAC with age, gender, hearing loss, and audiometric slope controlled as either individual or combination variables. As can be seen, the variables of age, gender, and audiometric slope had minimal influence on the overall AI and SAC or SOAC correlations

Table 2 Pearson Correlation Coefficients between AI and SAC and SOAC Total Raw Scores

	AI	*SAC*	*SOAC*
AI	1.00	−0.59*	−0.57*
SAC	−0.59*	1.00	0.82*
SOAC	−0.57*	0.82*	1.00

*p < .01.
SAC N = 373, SOAC N = 292.

either independently or in all other combinations with each other. That is, as the variables age, gender, and slope were partialled out of the overall correlations, the coefficients remained essentially unchanged and significant. Conversely, when the variable hearing loss was partialled out, the r's between SAC/AI and SOAC/AI were substantially diminished and became nonsignificant. The most likely explanation for the failure of age and gender to interact substantially with the AI and SAC/SOAC correlations is that neither of these two variables has a direct relationship to hearing sensitivity and communicative ability. It is not completely clear why audiometric slope failed to interact significantly with the AI and SAC/SOAC relationship; however, one possible explanation may be that the operational definition of audiometric slope used in this investigation served to obscure the actual impact of this variable. Finally, the degree of hearing loss, as expected, had a substantial influence on the AI and SAC or SOAC correlations both as an independent variable and in all combinations with the other variables. These findings reinforce the important influence that the degree of hearing loss has on both speech audibility and hearing handicap.

Table 3 Partial Correlation Coefficients between the AI and SAC/SOAC with Age, Gender, Audiometric Slope, and Hearing Loss Controlled as Individual and Combination Variables

Variable Controlled	*AI/SAC*	*AI/SOAC*
Age	−0.60*	−0.60*
Gender	−0.60*	−0.57*
Slope	−0.59*	0.56*
Hearing loss	−0.16	−0.10
All combinations controlled except hearing loss	−0.59 to −0.60*	−0.55 to −0.56*
All combinations controlled except hearing loss	−0.10 to −0.16	−0.07 to −0.09

* p <.01.
SAC N = 373, SOAC N = 292.

Table 4 Spearman Rank Order Correlation Coefficients between AI Values and Individual SAC/SOAC Items

Item	*AI/SAC*	*AI/SOAC*
1	−0.47*	−0.54*
2	−0.49*	−0.54*
3	−0.57*	−0.53*
4	−0.48*	−0.48*
5	−0.42*	−0.47*
6	−0.55*	−0.49*
7	−0.43*	−0.40*
8	−0.36*	−0.38*
9	−0.40*	−0.45*
10	−0.34*	−0.34*

* p < .01.
SAC N = 373, SOAC N = 292.

Table 4 presents the Spearman rank order correlations used to assess the relationship between the AI and each SAC/SOAC item. As expected, significant correlations existed between the AI and each handicap scale item. In general, communication-related items (items 1–6) correlated better with the AI than the social-emotional items (items 7–10). These findings suggest that speech audibility might directly influence communication-related items more than social-emotional items.

DISCUSSION

This investigation sought to determine the relationship between speech audibility measured by the AI and hearing handicap quantified by the SAC/SOAC scales. It was reasoned that since the AI and hearing handicap both provide information regarding the effects of hearing loss on communicative function, an inverse relationship would exist between AI and hearing handicap scores. It was not surprising, therefore, to find significant negative correlations (p < .01) between AI values and both the SAC and SOAC hearing handicap scales (see Table 2). That is, as AI values for participants decreased, perceived hearing handicaps increased. This finding supports conclusions from previous research that reported significant inverse relationships between SAC and/or SOAC scores and measures of hearing sensitivity (Sturmak, 1987; Kielinen and Nerbonne, 1990; Schow, 1995).

It is important to stress that the correlations between the AI and SAC/SOAC values were, at best, only moderately strong. Thus, although AI and hearing handicap measures were related significantly, the relationship was less than perfect. This finding has important implications for clinical practice. For example, the moderately strong correlations preclude confident prediction of AI values from hearing handicap data or vice versa. Clinical time and effort must be allocated to assess independently speech audibility and hearing handicap. Although the AI and SAC/SOAC both provide a measure of communicative function, it appears clear that they also assess additional variables that are independent of one another. The AI, for example, is dictated by the patient's residual hearing and does not necessarily reflect how individuals perceive their hearing loss. Neither does the AI factor in the extent to which individuals with hearing impairment use visual cues or employ other compensatory strategies during communication. Recall that when the variables of age, gender, degree of hearing loss, and audiometric slope were controlled as constants, either individually or in combination with one another, only degree of hearing loss had a substantial influence on the correlations of AI values with SAC and/or SOAC scores. Clearly, both the AI and hearing handicap scales are important considerations in effective patient management because each provides unique information regarding different aspects of the patient's communication difficulties.

Finally, it is interesting that those SAC/SOAC items concerned with communication (e.g., items 1–6) correlated better with the AI than the social-emotional items (e.g., items 7–10) (see Table 4). These findings imply that restrictions imposed on speech audibility as the result of hearing loss may influence communication-related endeavors more than social-emotional activities.

SUMMARY

The findings of this investigation revealed that a significant inverse relationship exists between AI values and perceived hearing handicap scores as measured by the SAC or SOAC. The degree of hearing loss had a major influence on the relationship between AI values and SAC or SOAC scores, whereas age, gender, and audiometric slope did not. Individual items of the SAC and SOAC designed to explore communicative skills (e.g., items 1–6) generally correlated better with AI values compared to items associated with feelings about communication (e.g., items 7–10). Although AI and hearing handicap correlated significantly, they should not be considered synonymous with respect to patient management because each provides a unique way of understanding the effects of hearing loss on communicative abilities.

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APPENDIX

Items of the SAC and SOAC* Scales

Various Communication Situations

1. Do you (**Does he/she**) experience communication difficulties in situations when speaking with one other person?
2. Do you (**Does he/she**) experience communication difficulties in situations when conversing with a small group of several persons?
3. Do you (**Does he/she**) experience communication difficulties while listening to someone speak to a large group?
4. Do you (**Does he/she**) experience communication difficulties while participating in various types of entertainment?
5. Do you (**Does he/she**) experience communication difficulties when in an unfavorable listening environment?
6. Do you (**Does he/she**) experience communication difficulties when using or listening to various communication devices?

Feelings about Communication

7. Do you feel that any difficulty with your (**his/her**) hearing limits hampers your (**his/her**) personal or social life?
8. Does any problem or difficulty with your (**his/her**) hearing upset you (**them**)?

Other People

9. Do (**you or**) others suggest that you (**he/she**) have (**has**) a hearing problem?
10. Do (**you or**) others leave you (**him/her**) out of conversations or become annoyed because of your (**his/her**) hearing?

*SOAC modifications are in bold.