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Style Preference Survey: A Report on the Psychometric Properties and a Cross-Validation Experiment

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Abstract

Background: Several self-report measures exist that target different aspects of outcomes for hearing aid use. Currently, no comprehensive questionnaire specifically assesses factors that may be important for differentiating outcomes pertaining to hearing aid style.

Purpose: The goal of this work was to develop the *Style Preference Survey* (SPS), a questionnaire aimed at outcomes associated with hearing aid style differences. Two experiments were conducted. After initial item development, Experiment 1 was conducted to refine the items and to determine its psychometric properties. Experiment 2 was designed to cross-validate the findings from the initial experiment.

Research Design: An observational design was used in both experiments.

Study Sample: Participants who wore traditional, custom-fitted (TC) or open-canal (OC) style hearing aids from 3 mo to 3 yr completed the initial experiment. One-hundred and eighty-four binaural hearing aid users (120 of whom wore TC hearing aids and 64 of whom wore OC hearing aids) participated. A new sample of TC and OC users (n = 185) participated in the cross-validation experiment.

Data Collection and Analysis: Currently available self-report measures were reviewed to identify items that might differentiate between hearing aid styles, particularly preference for OC versus TC hearing aid styles. A total of 15 items were selected and modified from available self-report measures. An additional 55 items were developed through consensus of six audiologists for the initial version of the SPS. In the first experiment, the initial SPS version was mailed to 550 veterans who met the inclusion criteria. A total of 184 completed the SPS. Approximately three weeks later, a subset of participants ($n = 83$) completed the SPS a second time. Basic analyses were conducted to evaluate the psychometric properties of the SPS including subscale structure, internal consistency, test-retest reliability, and responsiveness. Based on the results of Experiment 1, the SPS was revised. A cross-validation experiment was then conducted using the revised version of the SPS to confirm the subscale structure, internal consistency, and responsiveness of the questionnaire in a new sample of participants.

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Results: The final factor analysis led to the ultimate version of the SPS, which had a total of 35 items encompassing five subscales: (1) Feedback, (2) Occlusion/Own Voice Effects, (3) Localization, (4) Fit, Comfort, and Cosmetics, and (5) Ease of Use. The internal consistency of the total SPS (Cronbach's α = .92) and of the subscales (each Cronbach's $\alpha > .75$) was high. Intraclass correlations (ICCs) showed that the test-retest reliability of the total SPS (ICC = .93) and of the subscales (each ICC > .80) also was high. TC hearing aid users had significantly poorer outcomes than OC hearing aid users on 4 of the 5 subscales, suggesting that the SPS largely is responsive to factors related to style-specific differences.

Conclusions: The results suggest that the SPS has good psychometric properties and is a valid and reliable measure of outcomes related to style-specific, hearing aid preference.

Key Words: Custom fit, hearing aid style, hearing aids, hearing loss, open canal, outcome measures, preference, psychometrics, questionnaire

Abbreviations: BTE = behind the ear; CIC = completely in the canal; DI = directivity index; ICC = intraclass correlation; ITE = in the ear; MARS-HA = Measure of Audiologic Rehabilitation Self-Efficacy for Hearing Aids; OC = open canal; PCA = principal components analysis; RITA = receiver-in-the-aid; RITE = receiver in the ear; SADL = Satisfaction with Amplification in Daily Life; SPS = *Style Preference Survey*; SSQ = Speech, Spatial and Qualities of Hearing Scale; TC = traditional, custom fitted

INTRODUCTION

Hearing loss is relatively common, with approximately 10% of the population estimated to have some degree of sensorineural hearing loss (Kochkin, 2005a). Rehabilitation of hearing loss often begins with the selection of appropriate amplification systems. Data suggest that only 20–25% of adults with hearing loss actually use hearing aids (e.g., Popelka et al, 1998; Kochkin, 2005a). Some adults with hearing loss never pursue hearing aids. In other, more disturbing cases, patients obtain hearing aids but fail to use them (Kochkin, 2000; Kochkin, 2007a). In fact, Kochkin (2007a) reported that 16.2% of individuals who own hearing aids never wear them. While the reasons for hearing aid nonuse vary and include aspects of patients and their environment, they also often include factors related to hearing aid style (Popelka et al, 1998; Kochkin, 2005b; Kochkin, 2007b). Based on the literature and clinical experience, factors that may affect hearing aid style preferences include the following nonacoustic and acoustic variables: (1) cosmetics; (2) fit and comfort; (3) ease of use; (4) speed and convenience of service delivery; (5) feedback, (6) audibility, with its potential implications for speech understanding in quiet and in noise; (7) occlusion (objective and subjective); (8) sound quality of external sounds; (9) aided speech recognition ability in spatially separated noise; and (10) sound source localization (Cox, 1982; Upfold et al, 1990; Byrne et al, 1998; Popelka et al, 1998; Kochkin, 2000; Noe et al, 2000; Baumfield and Dillon, 2001; Moore and Tan, 2003; Kiessling et al, 2005; Kochkin, 2005a, 2005b; Kuk et al, 2005; Mueller and Ricketts, 2006; Taylor and Berkeley, 2007; West and Smith, 2007; Ricketts et al, 2008; Mueller, 2009). These factors are important because they can affect hearing aid nonuse as well as outcomes associated with hearing aid use. Clinicians are required to balance the potential benefits and limitations of each hearing aid style, even though it is not clear how these factors influence a specific patient.

Issues related to hearing aid style are of interest because the dispensation of behind-the-ear (BTE) hearing aids has increased from 33% in the second quarter of 2006, to more than 65% by the end of 2010. The increase in BTE market share has been attributed to the introduction of mini BTE styles including open canal (OC) styles (Strom, 2008; Hearing Industries Association, 2009; Kirkwood, 2010). The OC hearing aid style is one intervention option suggested as a remedy for many of the problems that result in nonuse, and perhaps nonpursuit, of traditional hearing aids (e.g., comfort, cosmetics, feedback, occlusion, sound quality, etc.), particularly for individuals with mild to moderately severe hearing losses. Traditional, custom-fitted (TC) hearing aid styles including in-the-ear (ITE), in-the-canal (ITC) and completely-in-the-canal (CIC) instruments typically require "closing" the ear canal for a tight coupling of the earmold or hearing aid shell to the ear. This tight fit is necessary to achieve sufficient amplification without producing acoustic feedback. With tight coupling, however, issues related to comfort and occlusion arise and must be managed.

Owing to the limited evidence available comparing outcomes between OC and TC hearing aid styles, clinical decisions regarding hearing aid style remain somewhat speculative. Consequently, we propose a metric to assess subjective preferences for hearing aid style (viz TC versus OC hearing aid styles). This metric has potential research and clinical utility. It could be used to compare preferences for different hearing aid styles fitted to the same population. It also could provide guidance to clinicians as they make hearing aid style recommendations for individual patients.

Choice of Style: Nonacoustic Factors

The choice of hearing aid style is expected to have both acoustic and nonacoustic implications for the hearing aid fitting. The nonacoustic implications are relatively straightforward and primarily are related to how style affects cosmetics as well as fit and comfort issues. Most clinicians have considerable experience with patients who express a strong desire for the smallest and most cosmetically appealing hearing aid available. In fact, cosmetic concerns are expressed so often that it would be reasonable to hypothesize that it dominates patients' concerns about hearing aid use. Surprisingly, however, one survey reported that 35% of those patients who currently do not have a hearing aid would not take an instrument even if the hearing aid was invisible and was free of cost (Kochkin, 2001).

However, there are data to indicate that fit and comfort of the earmold/earshell contributes to style preferences for traditional BTE and ITE instruments (Baumfield and Dillon, 2001). Improved wearing comfort also may contribute to the recent popularity of the OC hearing aid style (Taylor and Berkeley, 2007). The lightweight aspect of the miniature BTE instrument and the looser fitting, nonoccluding, open-ear tip (i.e., dome) may improve wearing comfort because open coupling reduces physical pressure on the ear canal and allows additional venting around the outside of the mold (i.e., slit leak).

Hearing aid style also can affect the ease of hearing aid use (e.g., Upfold et al, 1990). Smaller hearing aids and their smaller batteries are more difficult to manipulate, especially for patients with limited dexterity or visual impairment. Some of the most recent OC miniature BTE hearing aids, including the receiver-in-the-ear (RITE) and receiver-in-the-aid (RITA) styles, are as small as CIC and ITC products and present similar problems to patients when handling, cleaning, or manipulating the hearing aid controls. Ease of use may be a particular issue for the RITA configuration of the OC style. Specifically, Taylor and Berkeley (2007) have argued that the RITA thin tubes may be more susceptible to cerumen occlusion than other hearing aid styles. Though the tubes can be cleaned by threading a small plastic wire down the length of the tube, patients with poor dexterity or vision may have difficulty with this task. On the other hand, patients who are able to perform this task may enjoy benefits associated with fewer cerumen-related repairs than are likely to occur with hearing aid styles that place the receiver deeply in the ear canal such as RITE and CIC hearing aids.

The speed and convenience of service delivery is another nonacoustic factor that can impact hearing aid outcomes. Many OC style instruments use noncustomized ear tips that eliminate the need for ear impressions and the time it takes to build customized earmolds. Patients can get their hearing aids faster with possibly fewer office visits. Improved efficiency of service delivery could reduce the total cost per patient and improve hearing aid outcomes.

Choice of Style: Acoustic Factors

The choice of hearing aid style also can directly affect factors related to hearing aid acoustics. Most notably hearing aid style is expected to affect the following factors: (1) susceptibility to feedback due to differences in the distance between the sound inlet (to the microphone) and sound outlet (from the receiver); (2) available gain before feedback, which in turn is expected to limit audibility and potentially affect speech recognition in quiet and noise; (3) occlusion related to venting differences, which also can affect sound quality for the listener's own voice; (4) sound quality for external sounds due to venting differences; (5) speech recognition in spatially separated speech in noise due to differences in microphone location effects and directional microphone effectiveness; and (6) localization due to microphone location effects and venting differences.

Importantly, the acoustic implications of style selection are expected to interact with patient factors, most notably, the degree of hearing loss. While smaller hearing aids are often desirable for cosmetic reasons, it is well recognized that increasing gain leads to an increased susceptibility to feedback. For the hearing aid wearer, the annoyance caused by feedback drastically can reduce patient satisfaction with the instrument (Kochkin, 2003). In fact, 24% of hearing aid wearers reportedly are dissatisfied with their hearing aids due to whistling, a common complaint associated with feedback (Kochkin, 1997). Acoustic feedback, in addition, limits available gain (e.g., Cox, 1982), which reduces audibility, which in turn leads to reduced speech recognition in quiet and in noise (ANSI S3.5; American National Standards Institute [ANSI], 1997).

A common method of feedback management is to separate the physical distance between the sound inlet and sound outlet by selecting a larger BTE style hearing aid instead of an ITE instrument (Kuk, 1994). The use of larger instruments, however, can lead to complaints related to cosmetics and, if the complaint is significant enough, to decreased wearing time.

Another common method of managing feedback is to limit venting, especially in smaller custom products. Limiting venting with a tight fit or smaller intentional vent can decrease comfort and increase the occlusion effect (Kuk, 1994). The occlusion effect occurs when sound vibrations are conducted through the skull and cartilaginous portion of the ear canal and are trapped in the space between the tip of the hearing aid and the tympanic membrane (Grover and Martin, 1979). These vibrations are reflected back toward the tympanic membrane and increase the loudness perception of bone conducted sounds. Compared to sound levels in an open ear canal, tight occlusion of the ear canal can increase sound levels 20–30 dB in the 500–750 Hz region. The end result is that hearing aid wearers with tight-fitting earmolds report abnormal loudness for the sound of their own voice or sounds created when they are chewing. Rather than venting, the occlusion effect may be alleviated by fitting a hearing aid style that places the earshell tightly and deeply in the ear (down to the bony portion), very close to the tympanic membrane (Killion et al, 1988; Dempsey, 1990). This method decreases the magnitude of the occlusion effect by increasing impedance at the tympanic membrane, increasing the resonant frequency of the residual ear canal space, and reducing ear canal wall vibrations. Unfortunately, hearing aid styles employing a tight, deep fit are uncomfortable to many patients, although for some, the discomfort may be reduced by using pliable earmolds or earshells.

Recently, issues related to the interplay between venting to relieve occlusion and the potential for feedback have been able to be effectively addressed for many patients by increasing venting while limiting feedback via digital feedback suppression (DFS) algorithms (e.g., Kates, 1999; Ji et al, 2005; Boukis et al, 2007; Lee et al, 2007). Currently, it is possible to provide up to 15–26 dB more gain prior to feedback with the same venting configuration as utilized without DFS (e.g., Freed and Soli, 2006; Merks et al, 2006; Shin et al, 2007; Ricketts et al, 2008; Spriet et al, 2010). Importantly, an equivalent vent size of at least 3.5–4 mm is needed to eliminate complaints associated with occlusion (e.g., Kiessling et al, 2005; Kuk et al, 2005). This size is simply not possible in many of the smallest custom instruments. Therefore, while many of the factors related to feedback and occlusion are affected directly by venting decisions, these same factors are affected indirectly by choice of hearing aid style, at least within the constraints that style has on venting. Indeed, it is the ability to increase gain prior to feedback through DFS that has made the OC style of hearing aid possible for a broad range of patients with hearing loss.

The larger vents used in the OC style can reduce or even eliminate the occlusion effect, leading to improved sound quality for the own voice of the listener (Kiessling et al, 2005; Kuk et al, 2005). In addition to reducing occlusion, large vents can improve sound quality of external sounds by allowing audible low-frequency sounds to pass naturally into the ear canal for patients with normal or near-normal low-frequency hearing. In fact, audible low-frequency sound has been shown to be a critically important factor in overall sound quality (Toole, 1986a, 1986b; Gabrielsson et al, 1990, 1991; Moore and Tan, 2003). Data also show that hearing aid wearers express greater comfort with larger vents (e.g., MacKenzie et al, 1989; Kuk et al, 2005).

Despite continued improvements in feedback suppression technology, the largest vents, particularly the OC style, still have the potential to limit the amount of available gain before feedback. This limited gain before feedback may in turn reduce audibility, at least for patients with more than a moderate degree of hearing loss (Ricketts et al, 2008). In addition, large vents, or open-fit configurations allow amplified signals to leak out of the ear, making it difficult to provide adequate low-frequency gain for some patients. Increasing low-frequency gain to match typical real-ear prescriptive targets requires larger, more powerful receivers resulting in considerably greater battery drain. Further, high levels of low-frequency amplification can result in echoes and other artifacts. Consequently, for some OC products, manufacturers have chosen to limit the amount of available low-frequency amplification and only provide usable gain in the high frequencies.

Another potential limitation associated with the open venting configuration relates to directional benefit. Previous data demonstrate that increasing vent size decreases the measured directivity index (DI), particularly in the low frequencies (Ricketts, 2000). Further, the average DI is highly correlated with measured directional benefit in environments in which the noise sources surround the listeners (Ricketts et al, 2005). A significant decrease in directional benefit, therefore, is expected when using open rather than closed fittings and instruments with similar high (>4 dB) DI values across the frequency range.

Hearing aid style also may affect localization. Accurate sound localization has been recognized as important for sound source identification, survival, spatial orientation, and group communication, especially in noise (e.g., Noble et al, 1997). The importance of localization is evident for listeners with hearing loss in noisy group conversation. The effects of general hearing aid use on localization in the horizontal plane are somewhat unclear. Carefully controlled investigations have shown limited or no decrement in horizontal-plane localization as long as the signal is audible and the listener is using bilateral amplification and has had adequate time to acclimatize to the hearing aid style (see Byrne and Noble, 1998, for review). Localization ability in the horizontal plane may be degraded if the listener (1) has more than a mild hearing loss and is wearing a monaural hearing aid (Dermody and Byrne, 1975; Byrne et al, 1992); (2) has inadequate acclimatization time with new hearing aids (Noble and Byrne, 1991); or (3) has normal (or near normal) low-frequency hearing thresholds and vented hearing aids. It is speculated that good low-frequency hearing with vented hearing aids causes timing differences between low-frequency information (via unaided vented sound) and high-frequency information (processed and delayed by the hearing aid) that disrupts normal interaural time difference cues (Wightman and Kistler, 1992; Noble et al, 1998). Open venting used with the OC hearing aid style may exacerbate this potential localization problem. To date there has been little investigation of the possible effects of hearing aid style on localization. Given the potential for a significant effect, however, examination of localization may be important to gain a complete picture of style-specific, hearing aid factors.

Based on clinical experience and the literature reviewed above, at least ten factors can be identified that are likely to contribute to a patient's preference for a particular hearing aid style. These include (1) cosmetics; (2) fit and comfort; (3) ease of use; (4) speed and convenience of service delivery; (5) feedback; (6) audibility; (7) occlusion (objective and subjective); (8) sound quality for external sounds; (9) aided speech recognition in spatially separated noise (e.g., directional benefit); and (10) sound source localization. Of these factors, audibility and aided speech recognition can be measured directly using existing clinical techniques. Occlusion can be measured objectively using clinical techniques; however, the relationship between the magnitude of objective occlusion and individual patient perception varies. For example, one patient may find a 10 dB occlusion effect bothersome, whereas a second patient may not. Therefore, it appears prudent to gather patient perception data as well as physical data in order to obtain a more complete picture of the factors related to style-specific preference. Currently, we are unaware of a single outcome measure that allows for the assessment of hearing aid style on these factors in a systematic way. A metric that allows a valid and reliable assessment of hearing aid style-specific factors would be useful clinically to determine the most appropriate hearing aid style for individual patients. In addition, it also would be helpful as a research tool to compare effects of hearing aid styles on various groups of hearing aid users. Thus the goal of the present work was to develop such a measure, which we have called the *Style Preference Survey* (SPS). After the initial development of questionnaire items, the first experiment was conducted to refine the items and subscales used and to assess the validity and reliability of the SPS. In a second experiment, the initial SPS findings were cross-validated in a new sample of participants. The development of the initial questionnaire and each of the two experiments is described below.

INITIAL QUESTIONNAIRE DEVELOPMENT

The initial items on the SPS targeted several of the subjective factors previously cited as being potentially important for style-specific hearing aid outcomes. The factors represented in the initial SPS included (1) cosmetics; (2) fit and comfort; (3) ease of use; (4) speed and convenience of service delivery; (5) feedback; (6) subjective occlusion, including own voice effects; (7) sound quality; and (8) sound source localization. Additional items related to how important these factors were to hearing aid users also were included as initial SPS items. Items related to audibility and speech recognition in quiet and noise were not included because they can be measured relatively easily, objectively, and with current clinical techniques.

The initial development of the SPS began by reviewing several questionnaires currently available to identify items related to the factors of interest. A total of 15 items included in the initial SPS were modified from items previously used in the Speech, Spatial and Qualities of Hearing Scale (SSQ; Gatehouse and Noble, 2004), the Satisfaction with Amplification in Daily Life (SADL; Cox and Alexander, 1999, 2001), and the Measure of Audiological Rehabilitation Self-Efficacy for Hearing Aids (MARS-HA; West and Smith, 2007) questionnaires.[1] An additional 55 items were constructed by the authors' research team, resulting in a total of 70 items on the initial SPS. The response scale for each item ranged from 0 (completely disagree) to 10 (completely agree), in 1-unit intervals, with 5 representing neutral. A "not applicable" option also was available as a response for each item.

EXPERIMENT 1

The first experiment was conducted to refine the items initially included in the SPS and to determine the psychometric properties of the instrument.

Methods

Participants

The participants were recruited through examining the records from the audiology clinics at the Bay Pines, Florida, and Mountain Home, Tennessee, Veteran Affairs Healthcare Systems to identify veterans who had received hearing aids at least 3 mo but no greater than 3 yr prior to the study. In addition, the chart review was used to obtain demographic, audiometric, and hearing aid style data on the participants. Participants with comorbidity issues that would prevent them from completing the questionnaires (e.g., vision impairments, arthritis in the hands, cognitive dysfunction, etc.) were excluded from the study. A total of 184 participants were enrolled (mean age = 70.4 yr, SD = 8.5). All participants wore traditional custom-fitted, ITE hearing aids or OC hearing aids. All hearing aids were fitted binaurally using validated prescriptive methods and fitted using typical clinical procedures including real ear verification via probe microphone measures. A total of 120 participants wore TC hearing aid styles, of which 39 wore full shell hearing aids, 47 wore half shells, 14 wore in-the-canal hearing aids, and 20 had CIC style hearing aids. Sixty-four participants wore OC hearing aid styles. Because a part of the initial impetus for the development of the SPS was to have one outcome measure that could be used in a systematic investigation comparing hearing aid outcomes between TC and OC hearing aid styles, participants who wore behind-the-ear hearing aids with custom-fitted earmolds were excluded. Figure 1 shows the mean right ear audiogram (and one standard deviation) of the 184 participants (ANSI, 2004). There was no significant difference in the pure-tone thresholds between the right and left ears of the participants, and therefore, only the mean right ear audiogram is displayed in Figure 1.

Procedures

All procedures were approved by the Institutional Review Boards and Research and Development committees at both VA facilities prior to the initiation of the study. The SPS was mailed to 550 hearing aid users to complete and return to the respective laboratories at both sites. A total of 184 SPS questionnaires were completed, resulting in a 33.5% response rate. The participants who completed one copy of the SPS were mailed a second copy to complete approximately 3 wk later. A total of 83 participants completed a second copy of the SPS (45.1% response rate). The mean time between the completion of the first and second copies of the questionnaire was 25.9 days (SD = 8.8).

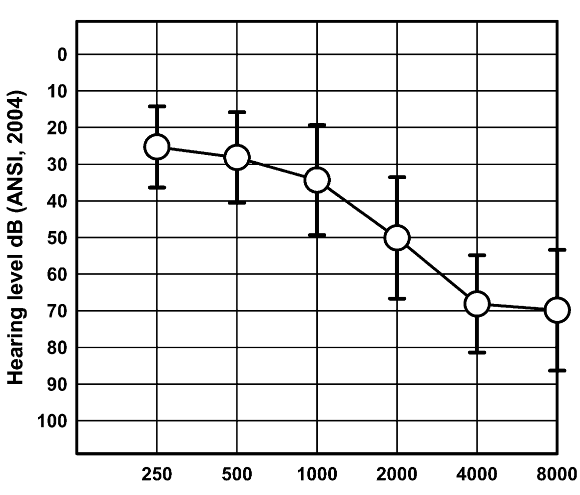

Figure 1. The mean pure-tone thresholds of the right ear of the 184 participants from the initial evaluation of the SPS questionnaire from Experiment 1. The error bars represent one standard deviation.

Results and Discussion

Standard validity and reliability analyses were conducted to determine the psychometric properties of the SPS. In particular, an exploratory factor analysis was conducted to determine the subscale structure for the SPS questionnaire. Internal consistency and test-retest reliability also were calculated for the SPS as a whole and for each of the subscales. Finally, the responsiveness of the SPS was evaluated to determine whether TC hearing aid users responded differently from OC hearing aid users on the SPS or any subscales of the SPS.

Factor Analysis

The subscale structure of the SPS was examined with a principal components analysis (PCA) with varimax rotation (Shaw, 2003). This analysis uses an orthogonal linear transformation to reveal the main factors underlying the structure of data in an unbiased way. Using this process, underlying factors are decomposed into vectors (Eigenvectors). From the Eigenvectors, eigenvalues and factor loadings are calculated that provide information about the contribution that each variable (in this case each scale item) makes to each component (in this case each underlying factor). The higher the eigenvalues (above 1) and factor loadings (above 0), the more strongly the scale items are positively correlated with the assumed underlying factor. This analysis also is used to calculate the variance accounted for by each factor when compared to the total data set. In Experiment 1, factor loadings .25 or greater, eigenvalues over 1.0, and factors accounting for at least 5% of the variance were used as criteria in interpreting the factor analysis. In the initial analysis, 24 items failed to load on any factor. Of these 24 items, one item each was related to localization, occlusion/own voice effects, and importance; two items were related to fit and comfort; three items were related to ease of use; and all items related to sound quality (9 items) and speed and convenience of service delivery (7 items) failed to load on any factor. These 24 items were deleted from the SPS and were not used in any additional analyses.

Six factors were identified from the analysis and together accounted for 56.1% of the variance. These factors were classified into the following six subscales, with the percent of the variance accounted for by each factor noted in parentheses: (1) Factor 1—Feedback (12.3%), (2) Factor 2—Localization (10.9%), (3) Factor 3—Occlusion/Own Voice Effects (10.4%), (4) Factor 4—Fit, Comfort, and Cosmetics (8.1%), (5) Factor 5—Ease of Use (7.2%), and (6) Factor 6—Importance (7.2%). The average factor loadings were .67 and ranged from .26 to .88.

Table 1 lists the factor loading values for each of the 46 remaining items making up the six factors identified

Table 1. Results of the Initial Factor Analysis and Descriptives for the Items, Subscales, and Total Scale from Experiment 1

Factor Loading	Mean	SD	Content
			Factor 1 (Feedback)
.68	5.9	3.6	I am bothered by an inability to get enough loudness from my hearing aids without feedback (whistling).*
.79	6.1	3.6	I am embarrassed or frustrated by sounds my hearing aid makes (whistling, screeching, etc.).*
.86	6.4	3.4	I get feedback (whistling) from my hearing aids when I move my head.*
.82	7.1	3.2	I get feedback (whistling) from my hearing aids when I chew/eat.*
.79	8.0	2.8	I get feedback (whistling) from my hearing aids when the room is quiet.*
.82	7.1	3.2	I get feedback (whistling) from my hearing aids when I am in a crowd or group.*
.57	4.4	3.8	I get feedback (whistling) from my hearing aids when I am using a telephone.*
.86	6.4	3.3	My hearing aids feedback (whistle) often.*
Subscale	6.4	2.7	
			Factor 2 (Localization)
.80	6.0	3.1	When I am in a noisy room and someone I am not looking at calls my name, I can tell where they are very quickly when I am wearing my hearing aids.
.81	5.2	3.0	When I am in a place where there are a lot of echoes, such as a church or auditorium, and someone I am not looking at calls my name, I can locate them very quickly when I am wearing my hearing aids.
.80	6.1	3.1	When I am with a group and the conversation switches from one person to another, I can easily follow the conversation without missing the start of what each new speaker is saying when I am wearing hearing aids.
.81	7.0	2.9	When I am outdoors in an unfamiliar place and I hear someone using a lawnmower but can't see where they are, I can tell right away where the sound is coming from when I am wearing my hearing aids.
.67	8.2	2.3	When I am sitting between two people and one of them starts to speak, I can tell right away whether it is the person on my left or right, without having to look when I am wearing my hearing aids.
.85	7.2	2.8	When I am in an unfamiliar house and it is quiet, then a door slams, I can tell right away where that sound came from when I am wearing my hearing aids.
.82	6.5	2.9	When I am outside and I hear a bird start to sing, I can tell right away where the sound is coming from without having to look when I am wearing my hearing aids.
Subscale	6.6	2.3	
			Factor 3 (Occlusion/Own Voice Effects)
.82	4.9	3.5	My own voice sounds hollow when I am my wearing hearing aids.*
.62	6.5	3.4	My own voice echoes in my head when I am my wearing hearing aids.*
.77	4.4	3.9	My own voice sounds loud to me when I am wearing my hearing aids.*
.56	7.2	2.9	My own voice sounds muffled to me when I am my wearing hearing aids.*
.67	5.2	3.5	I have trouble monitoring the volume of my own voice when I talk while I am wearing my hearing aids.*
.77	3.6	3.5	The sound of eating/chewing, especially crunchy food, is loud to me when I am wearing my hearing aids.*
.72	5.2	3.4	I hear the sound of my breathing when I wear my hearing aids.*
.55	6.1	3.1	The sound quality of my own voice is natural when I am wearing my hearing aids.
Subscale	5.4	2.5	
			Factor 4 (Fit, Comfort, and Cosmetics)
.52	7.2	3.2	I notice my hearing aids when they are in my ears because they are uncomfortable.*
.57	6.6	3.3	My hearing aids are so comfortable that I forget that I have them in my ears.
.56	7.3	3.0	After I have worn my hearing aids for several hours, they fit comfortably.
.43	6.2	3.6	At least one of my hearing aids is uncomfortable by the end of the day.*
.78	8.0	2.8	I am pleased with the appearance of my hearing aids.
.79	7.2	3.4	When I look in the mirror when I am wearing my hearing aids, I am concerned that they are noticeable.*
.44	8.7	2.2	I am pleased with the color of my hearing aids.
.73	7.4	3.2	I am self-conscious about how the hearing aids look in my ears.*
Subscale	7.3	2.1	

Table 1. Continued

Factor Loading	Mean	SD	Content
			Factor 5 (Ease of Use)
.53	8.9	2.3	I can tell the right hearing aid from the left hearing aid with ease.
.88	8.6	2.4	I can insert the batteries into my hearing aids with ease.
.88	8.6	2.3	I can remove the batteries from my hearing aids with ease.
.65	8.5	2.2	I can insert my hearing aids into my ears with ease.
.43	9.2	1.5	I am able to remove my hearing aids from my ears with ease.
Subscale	8.7	1.7	
			Factor 6 (Importance)
.26	9.6	0.9	It is important to me that I understand speech as well as possible with my hearing aids.
.80	9.1	1.4	It is important to me that other people talk naturally to me when I am wearing my hearing aids.
.71	8.9	1.7	It is important to me that music sounds natural to me when I am wearing my hearing aids.
.78	8.9	1.7	It is important to me that my own voice sounds natural to me when I am wearing my hearing aids.
.56	9.3	1.5	It is important to me that my ears don't feel "plugged up" when I am wearing my hearing aids.
.52	8.9	1.6	It is important to me that I can find sounds/people very quickly, even when I can't see what/who is making the sound.
.42	9.4	1.4	It is important to me that my hearing aids don't feedback (whistle) frequently.
.42	8.7	2.0	It is important to me that I don't notice my hearing aids because they are so comfortable in my ears.
.48	9.2	1.3	It is important to me that I can get my hearing aids in and out of my ears with ease.
.36	9.2	1.4	It is important to me that I can change the batteries in my hearing aids with ease.
Subscale	9.1	0.9	
Total Scale	7.3	1.2	

*Items that have reverse scoring.

on the SPS along with the individual item content, mean, and standard deviation. The not-applicable responses were not included in the mean score calculations. The mean individual item scores ranged from 3.6 (Item 14, Occlusion/Own Voice Effects) to 9.6 (Item 60, Importance), with a total item mean of 7.2. Higher scores are indicative of more positive outcomes. These results suggest that these hearing aid users overall have high outcomes with their hearing aids but that specific situations or features of hearing aids (e.g., occlusion with eating) may not be acceptable. The mean score (and standard deviation) for each subscale and the total scale also was calculated and are listed in Table 1.

To evaluate the SPS further, Pearson product moment correlations were calculated between the subscales and the total scale, and between each subscale. These correlations are listed in Table 2. The average correlation among the subscales was .17 and ranged from -−.02 to .44. These results suggest that the content of the subscales does not overlap, which supports the results of the factor analysis. The average correlation between the subscales and the total scores was .53 (r = .21 – .74). All of the subscales were significantly correlated with the total scale at the .01 level (two-tailed). Overall, this finding suggests that the subscales are well correlated with the total scale.

Reliability

Internal Consistency Reliability Cronbach's α reliability coefficient was used to determine the internal consistency for the total scale and for each subscale on the SPS. The Cronbach's α for each subscale and for the total scale are listed in Table 3 (column 2) along with the number of items (column 3). These results exceed the recommended internal consistency alpha levels of .70 (Nunnally and Burnstein, 1994; Hyde, 2000) and suggest that there is a strong relationship among the subscale items. These results also suggest that the set of items for the total scale are well integrated.

Test-Retest Reliability Test-retest reliability was assessed to determine whether the participant responses on the SPS were stable over time. Intraclass correlation (ICC) was used to calculate the test-retest reliability of the total scale and each subscale, using the first SPS administration as one half and the second SPS administration as the second half in the analysis. The test-retest reliability of the total scale was ICC = .93 and on average was ICC = .87 (range ICC = .81–.94) for the subscales. The test-retest reliability coefficients for the subscales and the total scale are listed in the last column of Table 3. As seen in the table, all of the coefficient values for test-retest reliability exceed .80. The test-retest reliability of the SPS thus is deemed high and suggests that the SPS is stable over time (Hyde, 2000).

Critical Difference Administering the SPS twice to the same individuals (n = 83) provided an opportunity for a 95% critical difference score to be estimated. The 95% critical difference scores were calculated for the initial SPS subscales and total scale for those who

Table 2. Pearson Product Moment Correlations among the Subscales and between the Total Scale and Each Subscale from Experiment 1

	Total Scale	Feedback	Localization	Occlusion/Own Voice Effects	Fit, Comfort, and Cosmetics	Ease of Use	Importance
Total Scale	1.00						
Feedback	.67	1.00					
Localization	.54	.13	1.00				
Occlusion/Own Voice Effects	.74	.37	.31	1.00			
Fit, Comfort, and Cosmetics	.66	.33	.14	.44	1.00		
Ease of Use	.35	.06	.04	.13	.28	1.00	
Importance	.21	.01	.04	-.02	.01	.20	1.00

completed the SPS under test-retest conditions. The participants also were divided into TC (n = 53) and OC user (n = 30) groups, and 95% critical difference scores were obtained for each group. These data are presented in Table 4. A practitioner could give the SPS under two conditions and use these scores to determine whether a significant difference was observed between the two test administrations for a given type of hearing aid user (i.e., TC, OC, or both).

Responsiveness An impetus for the development of the SPS was to have a reliable and valid measure of patient outcomes pertaining to style-specific hearing aid factors. In accordance with this goal, there was interest in developing a measure that could differentiate between specific styles of hearing aids, viz OC versus TC styles. The responsiveness of the SPS subscales and total scale, therefore, was evaluated between participants with open-canal versus traditional, custom-fitted hearing aids via a one-way analysis of variance (ANOVA) with Bonferroni corrections for multiple comparisons. The subscale means, total score means, the number of participants, the standard deviations, and the results of the ANOVA are shown in Table 5. In the table, the number of useable responses obtained was different for the subscale and total scale because not all participants responded to all items on the SPS, and thus, the *n* is not the same for each subscale.

As seen in Table 5, three mean subscale scores (i.e., Localization, Occlusion/Own Voice Effects, and Fit, Comfort, and Cosmetics) and the total scale mean score were significantly higher for OC hearing aid users than for TC hearing aid users ($p < .05$). These results demonstrate better overall outcomes, particularly in the three subscale areas, for OC hearing aid fittings. With the recent advancement in feedback suppression technologies, differences in scores on the Feedback subscale with TC and OC fittings may not have been sensitive for participants with mild to moderately severe sensorineural hearing losses (see average audiogram in Figure 1). If OC hearing aid styles are fitted on listeners with greater degrees of hearing losses, then concerns with feedback may arise and take more importance as an outcome domain of interest. Likewise, our participants were selected because they had no history of dexterity or visual impairments and thus may have had little difficulty with inserting and removing their hearing aids and batteries. We attribute the lack of statistically significant differences between TC and OC groups on the mean Ease of Use subscale, in part, due to the fact that the participants were preselected to have no significant dexterity or visual impairments. Another important consideration relates to the fact that all surveyed individuals were fitted clinically. That is, clinical fittings are generally appropriate for patients and would not result in large differences in a number of factors including presence of feedback, and difficulty with insertion/removal, because the presence of significant problems in these areas related to a single style would typically lead a clinician to select a more appropriate style at the fitting. Despite this conclusion, it is certainly possible for hearing aids to be fitted inappropriately. Further, it may be of interest to directly compare hearing aid styles within the same group of listeners using the SPS, and in such cases, vision and/or dexterity issues may be present across styles. Therefore, we opted to retain the Ease of Use and Feedback subscales for the next version of the SPS.

The Importance subscale mean scores were not statistically different between participants with TC and OC fittings, with the participants with TC hearing aids on average rating importance as 0.2 points higher than participants with OC hearing aids. However, it can be seen from Table 5 that the responses for the

Table 3. Results of the Initial Reliability Analyses for the SPS Subscales and Total Scale from Experiment 1

Subscale	Cronbach's α	# of Items	ICC
Localization	.91	7	.88
Occlusion/Own Voice Effects	.88	8	.94
Feedback	.91	8	.81
Fit, Comfort, and Cosmetics	.83	8	.90
Ease of Use	.77	5	.85
Importance	.80	10	.82
Total Scale	.90	46	.93

Note: ICC = intraclass correlation.

Table 4. 95% Critical Difference Scores Estimated for the Initial Version of the SPS Subscales and Total Scale for the TC (n = 53) and OC (n = 30) Hearing Aid Users Individually and When Grouped Together (n = 83)

Subscale	TC	OC	Both
Localization	1.03	0.74	0.73
Occlusion/Own Voice Effects	0.98	1.11	0.79
Feedback	1.14	1.30	0.89
Fit, Comfort, and Cosmetics	0.89	0.76	0.89
Ease of Use	0.63	0.89	0.51
Importance	0.30	0.59	0.29
Total Scale	0.51	0.60	0.42

Note: OC = open canal; TC = traditional, custom fitted.

Importance subscale from the SPS were at ceiling for both TC and OC hearing aid users. This led us to delete this subscale because ceiling responses provide minimal useful information when comparing across hearing aid style. However, this finding demonstrates that hearing aid users of all types of hearing aid styles rate sound quality, feedback, ease of use, and so forth, as being highly important to them. This finding further supports our choice of the subscales that were selected for inclusion in the SPS. Below, a new group of participants completed the refined SPS, and their responses will be described.

EXPERIMENT 2

The purpose of this experiment was to cross validate the revised version of the SPS (the 36-item SPS version) on a new group of respondents by repeating the factor analysis and re-examining the internal consistency. The responsiveness of the SPS subscales and total scale also was reevaluated. The respondents were part of a Veterans Affairs multisite (Bay Pines, FL; Mountain Home, TN; and Nashville, TN), cross-over, clinical trial examining the effects of OC and TC fittings on various style-specific factors. Only baseline SPS data from the clinical trial is reported here because data collection for the trial is ongoing and is beyond the scope of this manuscript.

Table 5. Mean Subscale and Total Scale Scores, Standard Deviations, *F*-Values, and *p*-Values for Participants with TC and OC Hearing Aids for the Initial SPS from Experiment 1

Subscale	Group	n	Mean	SD	*F*	*p*
Localization*	TC	120	6.3	2.5	6.5	.012
	OC	64	7.2	1.8		
Occlusion/Own Voice Effects*	TC	120	4.6	2.2	37.3	.000
	OC	64	6.8	2.3		
Feedback	TC	119	6.2	2.8	2.4	.126
	OC	63	6.8	2.6		
Fit, Comfort, and Cosmetics*	TC	119	6.9	2.2	9.8	.002
	OC	64	7.9	1.9		
Ease of Use	TC	119	8.6	1.7	2.2	.136
	OC	64	9.0	1.5		
Importance	TC	119	9.2	0.9	2.0	.159
	OC	63	9.0	1.0		
Total*	TC	120	7.0	1.1	21.4	.000
	OC	64	7.8	1.2		

*Statistically significant.

Methods

Participants

A total of 185 veterans (179 males and 6 females) completed the SPS at the time of this report (Bay Pines, n = 71; Mountain Home, n = 56; Nashville, n = 58). The mean age of the participants was 68.4 yr (SD = 9.3, range 42–85). There was a significant site difference for age in that the participants at Bay Pines were ~5 yr older on average than the participants at the other two sites (one-way ANOVA; F (2, 184) = 7.4, p = .001). A total of 91 participants were fitted with TC hearing aids, and 94 were fitted with OC hearing aids (RITA or RITE styles). There was not a significant site difference among the audiograms of the participants nor was there a significant difference in the audiograms of participants with TC versus OC hearing aid styles ($p > .05$). Thus, the average audiogram (and one standard deviation) of all 185 participants is illustrated in Figure 2 (ANSI, 2004).

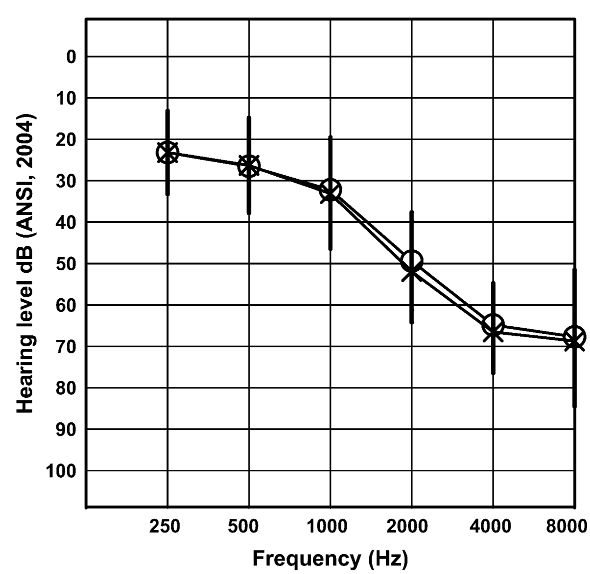

Figure 2. The mean pure-tone thresholds of the right and left ear audiograms of the 185 participants in the cross-validation experiment. The error bars represent one standard deviation.

Procedures

As part of the larger, multisite clinical trial, participants were fitted randomly with either an OC or TC hearing aid style bilaterally and wore that hearing aid style for 2 mo. At the 2 mo visit, the participants completed a battery of measures based on the current hearing aids that they were wearing for that arm of the clinical trial, one measure of which was the SPS. The SPS data from that visit are reported below.

Results and Discussion

Factor Analysis

As in the previous experiment, a PCA with varimax rotation was conducted for the revised 36-item version of the SPS (recall that 24 items that did not load significantly on to any factor and the Importance items from the previous SPS version were not used in this current SPS version). Again, the criteria for interpreting the results of the factor analysis included factor loading values of .25 or greater, minimum eigenvalues of 1.0, and factors accounting for at least 5% of the variance. We anticipated a five-factor solution given that the Importance subscale was removed from this version of the SPS. The results of the PCA were nearly identical to those found in the previous experiment, except that item 32 failed to load on any factor. Thus, Item 32 was deleted from this version of the SPS and not used in any subsequent analysis, resulting in a total of 35 items for the final version of the SPS (Figure S1, supplemental to the online version of this article).

As expected, the PCA results confirmed five factors, or subscales, that were found as with the earlier version of the SPS, accounting for 59.0% of the variance. The percent variance explained for each subscale is in parentheses as follows: Factor 1—Feedback (15.4%); Factor 2–Occlusion/Own Voice Effects (13.1%); Factor 3—Localization (12.7%); Factor 4—Ease of Use (9.1%); and Factor 5—Fit, Comfort, and Cosmetics (8.7%). Table 6 lists the factor loading values and descriptives for each item, and the descriptives for each subscale and the total scale, for this cross-validation analysis in this new sample of respondents. The mean factor loading value was .70 (range .45 to .85), which was similar to the previous PCA results from the earlier version of the SPS. This confirms that the subscale structure of the SPS was stable in a new sample of respondents.

Internal Consistency Reliability

Cronbach's α again was used to calculate the internal consistency reliability of the final, 35-item version SPS subscales and total scale. The Cronbach's α results were as follows: (1) Feedback, $\alpha = .90$, (2) Occlusion/Own Voice Effects, $\alpha = .86$, (3) Localization, $\alpha = .88$, (4) Fit, Comfort, and Cosmetics, $\alpha = .79$, (5) Ease of Use, $\alpha = .79$, and (6) Total SPS, $\alpha = .92$. These results confirm that the final version of the SPS subscales and total scale has good internal reliability.

Responsiveness

Cross-Validation Sample As in the previous experiment, the SPS was designed to evaluate factors that may help differentiate between preferences for hearing aid style. A one-way ANOVA with Bonferroni corrections was conducted to evaluate the responsiveness of the final, 35-item SPS version comparing OC versus TC hearing aids. The results are listed in Table 7. In this new sample of respondents using the final SPS, the OC hearing aid users had significantly higher (better) outcomes than the TC hearing aid users for the total score and all the subscales except for the localization and feedback where there was no significant difference between the two user groups. Unlike the earlier version of the SPS in Experiment 1, the responsiveness of the Localization subscale on the final SPS version was not significantly different between TC and OC hearing aid users. The similarities in localization between users of the two styles of hearing aids may be because the new sample of participants all received the same make and model of hearing aid with the only difference being style. They also were fitted with special care to meet real-ear prescriptive targets required by the clinic trial. In the previous sample drawn from a clinic population, the hearing aid users received hearing aids of various makes and models and real-ear outputs were allowed to deviate from targets to accommodate patient preference, which may have contributed to localization differences observed between the two samples.

As with the first sample and earlier version of the SPS, no significant differences were noted between the TC and OC hearing aid users on the Feedback subscale. This suggests that this subscale may not be responsive to hearing aid style differences. It is possible that advances in the feedback management systems in modern hearing aids may have made feedback problems between the different hearing aid styles less relevant. Responses on the final version of the Feedback subscale were evaluated further by examining differences based on the degree and the configuration of the hearing loss of the participants, which were grouped into the following four categories based on pure-tone thresholds: (1) 250–1000 Hz thresholds $\leq$25 dB HL, 2000 Hz of 30 to 60 dB HL, 3000 and 4000 Hz of 30 to 65 dB HL; n = 24; (2) 250 Hz threshold $\leq$25 dB HL, 500 and 1000 Hz thresholds of 30 to 60 dB HL, 2000 Hz of 30 to 60 dB HL, 3000 and 4000 Hz of 30 to 65 dB HL; n = 113; (3) 250 Hz thresholds $\leq$50 dB HL, 500 and 1000 Hz thresholds of 50 to 65 dB HL, 2000 Hz thresholds of 60 to 75 dB HL, 3000 Hz thresholds of 65 to 80 dB

Table 6. Results of the Cross-Validation Factor Analysis and Descriptives for the Items, Subscales, and Total Scale Using the Second Version of the SPS in a New Sample of Respondents from Experiment 2

Factor Loading	Mean	SD	Content
			Factor 1 (Feedback—8 Items)
.65	7.6	2.7	I am bothered by an inability to get enough loudness from my hearing aids without feedback (whistling).*
.71	7.9	2.8	I am embarrassed or frustrated by sounds my hearing aid makes (whistling, screeching, etc.).*
.84	8.0	2.8	I get feedback (whistling) from my hearing aids when I move my head.*
.82	8.3	2.4	I get feedback (whistling) from my hearing aids when I chew/eat.*
.82	8.7	2.2	I get feedback (whistling) from my hearing aids when the room is quiet.*
.85	8.4	2.3	I get feedback (whistling) from my hearing aids when I am in a crowd or group.*
.54	6.8	3.3	I get feedback (whistling) from my hearing aids when I am using a telephone.*
.82	8.2	2.6	My hearing aids feedback (whistle) often.*
Subscale	8.0	2.1	
			Factor 2 (Occlusion/Own Voice Effects—8 items)
.74	4.3	3.3	My own voice sounds hollow when I am my wearing hearing aids.*
.78	6.0	3.4	My own voice echoes in my head when I am my wearing hearing aids.*
.79	3.7	3.3	My own voice sounds loud to me when I am wearing my hearing aids.*
.57	7.1	2.8	My own voice sounds muffled to me when I am my wearing hearing aids.*
.70	5.3	3.2	I have trouble monitoring the volume of my own voice when I talk while I am wearing my hearing aids.*
.69	3.1	3.0	The sound of eating/chewing, especially crunchy food, is loud to me when I am wearing my hearing aids.*
.67	5.5	3.5	I hear the sound of my breathing when I wear my hearing aids.*
.59	5.9	3.0	The sound quality of my own voice is natural when I am wearing my hearing aids.
Subscale	5.1	2.3	
			Factor 3 (Localization—7 Items)
.79	6.9	2.1	When I am in a noisy room and someone I am not looking at calls my name, I can tell where they are very quickly when I am wearing my hearing aids.
.78	6.0	2.3	When I am in a place where there are a lot of echoes, such as a church or auditorium, and someone I am not looking at calls my name, I can locate them very quickly when I am wearing my hearing aids.
.69	7.3	2.0	When I am with a group and the conversation switches from one person to another, I can easily follow the conversation without missing the start of what each new speaker is saying when I am wearing my hearing aids.
.75	7.3	2.3	When I am outdoors in an unfamiliar place and I hear someone using a lawnmower but can't see where they are, I can tell right away where the sound is coming from when I am wearing my hearing aids.
.53	8.8	1.5	When I am sitting between two people and one of them starts to speak, I can tell right away whether it is the person on my left or right, without having to look when I am wearing my hearing aids.
.82	7.6	2.2	When I am in an unfamiliar house and it is quiet, then a door slams, I can tell right away where that sound came from when I am wearing my hearing aids.
.80	7.4	2.1	When I am outside and I hear a bird start to sing, I can tell right away where the sound is coming from without having to look when I am wearing my hearing aids.
Subscale	7.3	1.6	
			Factor 4 (Fit, Comfort, and Cosmetics—8 Items)
.55	7.6	2.7	I notice my hearing aids when they are in my ears because they are uncomfortable.*
.45	7.1	3.0	My hearing aids are so comfortable that I forget that I have them in my ears.
.46	7.8	2.6	After I have worn my hearing aids for several hours, they fit comfortably.
.49	7.4	3.1	At least one of my hearing aids is uncomfortable by the end of the day.*
.70	8.3	2.2	I am pleased with the appearance of my hearing aids.
.71	7.7	3.0	When I look in the mirror when I am wearing my hearing aids, I am concerned that they are noticeable.*
.54	8.9	1.9	I am pleased with the color of my hearing aids.
.72	7.9	2.8	I am self-conscious about how the hearing aids look in my ears.*
Subscale	7.8	1.7	

Table 6. Continued

Factor Loading	Mean	SD	Content
			Factor 5 (Ease of Use—4 Items)
.80	8.9	1.8	I can insert the batteries into my hearing aids with ease.
.81	9.0	1.9	I can remove the batteries from my hearing aids with ease.
.68	8.8	1.8	I can insert my hearing aids into my ears with ease.
.74	9.3	1.4	I am able to remove my hearing aids from my ears with ease.
Subscale	9.0	1.4	
Total Scale	7.4	1.3	

*Items that have reverse scoring.

HL, and 4000 Hz thresholds of 65 to 85 dB HL; n = 41; and (4) other configurations that did not meet the above three hearing loss categories; n = 6. The results of the one-way ANOVA approached significance ($p = .08$); however, the responses of the Feedback subscale were still not significantly different based on any category of hearing loss. A final analysis was conducted comparing the results on the Feedback subscale controlling for both hearing aid style (OC versus TC) and hearing loss category, but again, no significant differences were found. This finding may be because the majority of participants fell into hearing loss category 2, and there were fewer participants in the hearing loss categories 1 and 3. Another reason may be that the hearing aids fitted in the cross-validation sample were done so as part of a larger, multisite clinical trial in which special care was taken to fit the hearing aids (same make and model) to a prescriptive target without feedback. Moreover, the hearing aids in the cross-validation experiment used newer technology compared to those used in the initial, clinic sample from Experiment 1 and may reflect advances in feedback suppression algorithms.

Cross-Validation Sample Compared to Initial Sample
The scores of the final SPS subscales and total scale were compared between the new sample of respondents (n = 185) in the cross-validation experiment (Experiment 2) and initial sample (n = 184 from Experiment 1) to evaluate further the responsiveness of the final SPS. Given that the participants in the initial sample completed the initial version of the SPS, their SPS scores were recalculated using the 35 items from the final SPS version so that a direct comparison between the samples could be made.

A one-way ANOVA with Bonferroni corrections was conducted to compare the subscale and total scale means between the two samples. The cross-validation sample had higher (better) subscale scores on the Localization ($F[1,368] = 11.6, p = .001$), Feedback ($F[1,366] = 36.7$, $p = .000$), and Fit, Comfort, and Cosmetics ($F[1,367] = 7.2, p = .008$) subscales compared to the initial sample. The scores on the Ease of Use subscale between the samples approached, but failed to reach, significance $F[1,366] = 3.4, p = .067$), however, there were only four subscale items that remained on the final version of the SPS. The total SPS scale and the Occlusion/Own Voice Effects subscale scores were not significantly different between the samples ($p > .05$). These results suggest that the sample of participants in the cross-validation experiment had higher hearing aid outcomes on three subscales than the initial sample, but not for the overall total scale. This finding is most likely because the cross-validation sample is part of a larger, multisite clinical trial, who likely received more attention during their fittings compared to the initial sample who was seen routinely in a clinical setting. Also, the cross-validation sample was fitted with slightly newer hearing aids of the same make and model compared to the initial sample. These differences between the samples may have contributed to the higher outcomes on the Localization, Feedback, and Fit, Comfort, and Cosmetics subscales for the cross-validation sample.

The differences between the two samples when further separated by hearing aid style also were evaluated, and the mean scores (and one standard deviation) are plotted in Figure 3. As seen in the figure, the SPS responses from the TC and OC users from both samples are similar except for two subscales: Occlusion/Own Voice Effects and Feedback. On the occlusion effect

Table 7. Mean Subscale and Total Scale Scores, Standard Deviations, *F*-Values and *p*-Values for 91 Participants with TC and 94 participants with OC Hearing Aids for the Final Version of the SPS Used in Experiment 2

Subscale	Group	Mean	SD	*F*	*p*
Localization	TC	7.1	1.6	2.5	.114
	OC	7.5	1.6		
Occlusion/Own Voice Effects*	TC	4.2	2.1	35.8	.000
	OC	6.0	2.1		
Feedback	TC	7.9	2.0	0.2	.678
	OC	8.0	2.3		
Fit, Comfort, and Cosmetics*	TC	7.3	1.8	16.7	.000
	OC	8.3	1.5		
Ease of Use*	TC	8.5	1.6	23.4	.000
	OC	9.4	.8		
Total*	TC	7.0	1.2	23.6	.000
	OC	7.9	1.2		

Note: The degrees of freedom and error for each subscale and total scale were 1, 184. OC = open canal; TC = traditional, custom fitted. *Statistically significant.

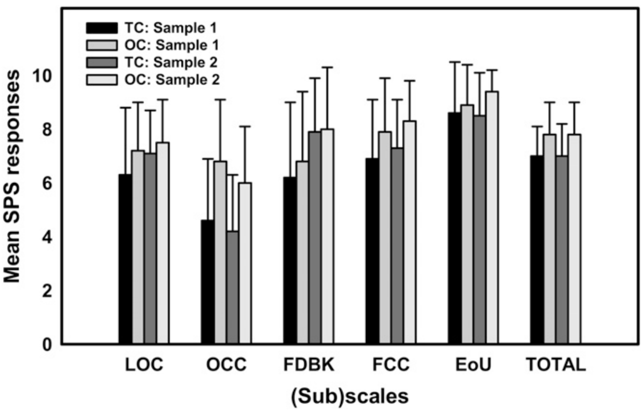

Figure 3. The mean SPS subscale and total scale responses from the TC and OC users from the two samples used in the current two experiments. The error bars represent one standard deviation. LOC = Localization; OCC = Occlusion/Own Voice Effects; FDBK = Feedback; FCC = Fit, Comfort, and Cosmetics; EoU = Ease of Use.

subscale the cross-validation sample had lower scores for both styles of hearing aids compared to the initial sample. Again, this may be because the initial sample is a clinical sample with varied hearing aid makes and models whereas the cross-validation sample had the same make and model of hearing aid that was meticulously fitted according to a research protocol. In the clinical (initial) sample, vent sizes and domes styles were not controlled for in the various makes and models of hearing aids used, and real-ear outputs were allowed to deviate from the target to control for complaints of the occlusion effect. In the cross-validation sample, the domes used were identical in the OC hearing aids, and the vent sizes in the TC hearing aids were all set at 2 mm, while they were allowed to vary in the initial, clinic sample. The opposite trend is noted for the feedback subscale where the participants in the cross-validation group had better outcomes than participants in the initial sample. The cross-validation sample used newer hearing aids and were the same make and model with a more advanced feedback management algorithm than the hearing aids used in the clinic sample (initial). These differences may account for the differences observed in Figure 3 between the samples and hearing aid styles seen on these two subscales.

Overall, the responsiveness of most of the SPS subscales and total scale is good as demonstrated by both the initial and cross-validation experiments and the comparison between SPS scores from the two samples. The Feedback subscale was not responsive to hearing aid style differences within either experiment; however, differences were noted on the subscale when comparing the two different samples from the two experiments. As a result, we opted to keep the Feedback subscale as part of the final SPS as there appeared to be a trend for differences within the sample and because future investigations and clinical fittings using open-canal, hearing aid styles are extending the fitting range of these instruments on patients with more significant degrees of hearing loss in which feedback may become an issue.

Normative Data Given that two samples were used in the two experiments (i.e., clinic [Experiment 1] and research [Experiment 2] samples) using the same two styles of hearing aids (i.e., TC and OC), combining both samples into one larger sample offers a wider representation of various hearing aid fittings for the purposes of normative data. Figure 4 illustrates the 20th, 50th, and 80th percentile scores for the total SPS score and each subscale for each hearing aid style combined across both samples (n = 369) in the top panel and when both samples and hearing aid styles were combined (lower panel). Both sets of norms in Figure 4 will allow clinicians or researchers to compare their SPS scores based on a user or user group wearing a specific hearing aid style (top panel) or when combined for a group of hearing aid users wearing both TC and OC styles (bottom panel). If a particular patient or group of patients fall below the respective normative value for a given subscale, then hearing aid adjustments and/or counseling could be warranted to increase the outcomes for the particular subscale. On the other hand, if the responses meet or exceed the normative values, then the clinician

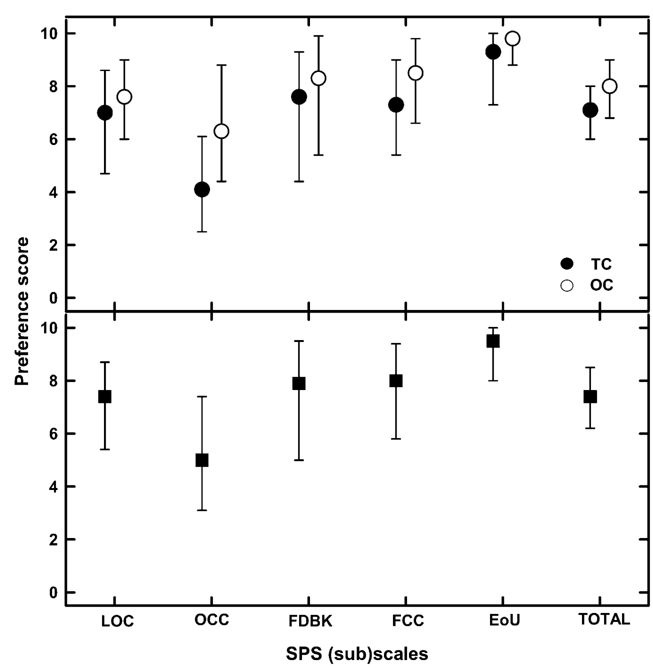

Figure 4. The 50th percentile scores for TC users (filled circles; n = 211) and OC users (open circles; n = 158) are illustrated for the combined samples from both experiments in the top panel. The bottom panel illustrates the 50th percentile responses collapsed across both samples and both hearing aid styles (filled squares, n = 369). The 20th *(bottom bar)* and 80th *(top bar)* percentile responses also are illustrated in each panel. LOC = Localization; OCC = Occlusion/Own Voice Effects; FDBK = Feedback; FCC = Fit, Comfort, and Cosmetics; EoU = Ease of Use.

or researcher can be confident that the outcomes for their patient or group of patients are similar to others.

SUMMARY AND CONCLUSIONS

The purpose of the present two experiments was to develop and validate a questionnaire to evaluate patient outcomes between OC versus TC hearing aid fittings that may be important indicators for style preference. The SPS was developed as part of the initial experiment. Minor refinements were made based on the results of the cross-validation experiment. The final version of the SPS contains 35 items that make up five subscales related to the following: (1) feedback, (2) occlusion/own voice effects, (3) localization, (4) fit, comfort, and cosmetics, and (5) ease of use. Overall, the two experiments demonstrated that the SPS has good internal consistency and test-retest reliability, at least in a veteran population. The results from the between-group analyses in both experiments indicated that participants fitted with OC hearing aids overall had higher (better) scores than did participants fitted with TC hearing aids, except on the feedback subscale. The overarching conclusion from this study, thus, was that the SPS has strong psychometric properties and largely is responsive to differences between OC and TC hearing aid fitting outcomes.

Approximately 5–10 min is required to complete the final, 35-item version of the SPS in a pen-and-paper format, which is clinically feasible. We envision, therefore, that the SPS may be useful in several applications. First, clinicians interested in assessing hearing aid outcomes in the areas measured on the SPS (i.e., feedback, occlusion/own voice effects, localization, fit, comfort, and cosmetics, and ease of use) could administer the questionnaire and compare their patient responses to the normative data presented here. The areas assessed on this measure have the potential to affect patient outcomes, and they are not comprehensively addressed in any other self-report outcome measures. A second application might be to assist audiologists when making style recommendations for patients looking to replace a current hearing aid. A third clinical application of the SPS might be to monitor outcomes of groups of patients as a function of hearing aid style to evaluate clinic protocols or other administrative aspects related to fitting. Given the recent increase in research endeavors with OC hearing aid technologies, which was the original motivation for developing the SPS, future investigations examining the differential outcomes of factors related to style preferences between OC and more traditional hearing aid fittings can incorporate the SPS as an outcome measure.

NOTE

1. The authors of the SSQ (Bill Noble), SADL (Robyn Cox and Ginny Alexander), and MARS-HA (Robin West and Sherri Smith) granted us permission to use or modify the items from their questionnaires and include the content of the items on the SPS.

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