The President’s Council of Advisors on Science and Technology (PCAST) 2015 report that was submitted to the U.S. Government last October has sparked much debate about the future provision of hearing health care in the U.S. The report primarily aimed to forward recommendations that will make hearing technology more accessible and affordable for a growing number of Americans living with hearing loss. To achieve this, the report suggests that direct-to-consumer sale of hearing aids, which can lower the cost of devices, be approved; and that the cost of hearing services be made more affordable and transparent by introducing an unbundled pricing structure for hearing health care. The latter strategy would ensure that hearing-impaired people who choose to buy a cheaper device on the direct-to-consumer market are not denied access to diagnostic and counselling services. Similar recommendations are largely corroborated in a recent report released by the Committee on Accessible and Affordable Hearing Health Care for Adults (Blazer. National Academies Press, 2016).

**SELF-FITTING HEARING AIDS**

The two reports endorse a growing range of products—currently only accessible online—that provide the user with optional access to software for independent fine-tuning of a preprogrammed hearing aid or self-managing the entire fitting process—called self-fitting hearing aids. While such products have been accessible for a few years now, limited information is available on their potential benefit and performance relative to conventional hearing aids that have been dispensed by a hearing health professional (Trends Hear. 2016;12;20). Not surprisingly, one of the major concerns expressed by hearing health practitioners surrounds this lack of evidence. Preliminary data suggest that self-adjustable hearing apps for smartphones provide outcomes comparable to those obtained with basic hearing aids, and therefore, may serve well as an introduction to amplification for people with milder hearing loss (The Hearing Review 2014). Through a series of studies done over the past six years at our laboratory, we have gained important knowledge on the management of the self-fitting process and on the efficacy and reliability of fine-tuning hearing aids in the field (Trends Amplif. 2011;15[4]:196; Int J Audiol. 2013;52[6]:385; J Am Acad Audiol. 2015;26[1]:5; J Am Acad Audiol. 2016). While these studies largely support the feasibility of self-fitting and self-adjustable devices, they also identified a number of improvements that are anticipated to improve overall outcomes (Trends Hear. 2016;12;20). Ultimately, however, we need to examine how the benefit, satisfaction, and performance capabilities of self-adjustable and self-fitting hearing aids compare with professionally fitted hearing aids.

**STUDY METHOD**

We conducted a study to examine how well both experienced and inexperienced hearing aid users can manage the self-directed fitting process associated with a prototype of the Companion, a commercially available self-fitting hearing aid from SoundWorldSolutions (Int J Audiol. 2013; 52[11]:795). Experienced hearing aid users who had completed all steps of the self-fitting procedure accurately according to a set of instructions and achieved fine-tuned settings considered by the experimenter to be safe to wear in
everyday life took part in a six-week field trial. A range of subjective and objective outcomes were measured at the end of the trial. The outcome measures were also performed on the participants’ own hearing aids, and the order in which the two device types were tested was counterbalanced across the group.

Eleven participants met the criteria for inclusion but only five were able to complete the field trial and provide outcome measures with both their own hearing aids and the test devices. These data have never been published before and do not present strong evidence due to the small sample size, but this paper illustrates what may be expected from self-fitted

Figure 1. The mean 2 cc coupler gain of the field trial participants’ (N = 5) preferred use gain in the test devices and their own hearing aids as measured at the end of each trial period. Error bars represent the 95 percent confidence intervals.

Figure 2. The mean SRT50 values measured for each of five participants with own devices and test devices, together with the grand means. Error bars represent the standard deviation.
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Figure 3. For each participant, the relationship between loudness ratings assigned each device at each input level until the maximum rating of six was reached for either device. The black dotted line shows unity.

Figure 4. The mean global scores measured for each of five participants with own devices and test devices, together with the grand means, on the IOI-HA (top), APHAB (middle), and SSQ12 (bottom).

hearing aids currently sold through the direct-to-consumer channel.

The five participants who completed the field trial were all males 72 to 79 years old. They all had symmetrical sloping hearing loss with a mean pure-tone average (PTA) of 47.1 dB HL (range = 36 to 61 dB HL) and had worn hearing aids for an average of 9.5 years (range = 4 to 38 years). They all entered the study as bilateral users of advanced technology; they wore receiver-in-canal (RIC) behind-the-ear (BTE) hearing aids from—Blamey & Saunders, GN ReSound, Rexton, and Sivantos.

The test hearing aid was also a RIC BTE instrument that featured 16-channel compression, noise reduction, feedback cancellation, and a directional microphone. Self-fitting of the test devices took place in a large sound-treated room. Participants were provided with a set of written, illustrated instructions collaboratively produced by the experimenter and device manufacturer. If possible, the participants brought a family member or friend along who could assist with the self-fitting process when needed. No one else was present in the test room during self-fitting, but participants were monitored via headphones and a webcam.

To fit the hearing aids, participants had to select appropriate instant-fit domes from three size ranges and adjust the retractable tubes for the devices to sit comfortably over the pinna. The aids were wirelessly paired via Bluetooth with a Samsung Galaxy tablet. Participants then accessed SoundWorldSolutions’ CS Customizer app to perform a self-directed pure tone hearing test and fine-tuning adjustments. The controls on the fine-tuning screen, laid out like a graphic equalizer, enabled participants to make adjustments to overall gain as well as gain in the low-, mid-, and high-frequency bands within a range of ±12 dB. Since participants did not have access to the self-fitting app during the field trial, no further permanent adjustments could be made to their settings after the self-fitting session; however, they were able to adjust overall gain to their preferred levels while in the field by using the hearing aids’ on-board controls.

Outcome measures collected with the test devices and the participants’ own devices included the signal-to-noise ratio (SNR) at which 50 percent speech intelligibility was achieved when listening to speech in noise (SRT50), loudness perception of wideband speech, and perceived benefit and satisfaction.

SRT50 was measured with an automated version of the Beautifully Efficient Speech Test (BEST). The noise level was fixed at 55 dB SPL, while the speech level varied adaptively throughout the test from a starting level of 65 dB SPL. Speech
was presented to the participant from a loudspeaker at 0° azimuth while uncorrelated 8-talker babble was presented from four loudspeakers positioned at ±45° and ±135°. The test continued until a minimum of 16 sentences were presented and a test-retest standard error of 0.8 dB was reached, or a maximum of 32 sentences were administered (Int J Audiol. 2013;52[11]:795). The BEST lists were scored morphemically. Three lists were presented and the results averaged to yield a single robust SRT50 score.

Loudness perception of wideband speech was measured by presenting single sentences spoken by a male talker at increasing levels, beginning at 45 dB SPL and ascending in 3 dB steps to a maximum presentation level of 75 dB SPL. Participants were asked to rate the loudness of each presentation using a seven-point categorical loudness scale (Ear Hear. 1997;18[5]:388) until Level 6 (“Loud, but Ok”) was reached. Three test runs were performed. Results of the first run were discarded as practice, and the median categorical loudness rating for each presentation level from the last two runs were then calculated to obtain the loudness growth function.

Self-reported benefit, satisfaction, participation restriction, and perceived performance were probed through three questionnaires: the International Outcome Inventory for Hearing Aids (IOI-HA) (Int J Audiol. 2002;41[1]:30), the Abbreviated Profile of Hearing Aid Benefit (APHAB) (Ear Hear. 1995;16[2]:176), and the short form of the Speech, Spatial and Qualities of Hearing Scale (SSQ12) (Int J Audiol. 2013;52[6]:409). On all questionnaires, higher ratings were associated with greater benefit and satisfaction and less participation restriction.

STUDY RESULTS

Figure 1 compares the average 2 cc coupler gain of the walk-in-the-door responses in the test device with that obtained from the participants’ own devices. According to a repeated-measures analysis of variance (ANOVA), preferred gain levels in the test device were significantly higher than the use gain levels in the participants’ own devices at 250 (p = 0.002), 500 (p = 0.01), and 6000 Hz (p = 0.0002). Across the individuals, the root-mean-square (rms) difference between the responses, calculated across ears and audiometric frequencies from 250 to 6000 Hz varied from 6.9 to 16.9 dB (or from 6.4 to 13.5 dB when excluding 6000 Hz).

Figure 2 shows the mean of three independent measures of SRT50 obtained for each participant with each device and the group mean. Lower values here mean better performance. Four of the five participants performed slightly better with their own devices, with the largest individual difference in SRT50 being 1.5 dB (participant 2). However, according to a t-test for dependent samples, the mean difference of 0.7 dB across participants did not reach significance (p = 0.06).

Figure 3 shows the relationship between the loudness ratings assigned to each device at each SPL for each participant. Points falling above the unity line indicate that the test device was rated louder than owned device at the same SPL. On average, across participants, the test devices were rated
Making the self-fitting process simple, intuitive, and accessible to a wide range of hearing aid candidates is definitely a challenge, but we anticipate that the optimal implementation of the automated fitting processes, complemented by comprehensive instructional and support materials, could reduce barriers to access and ensure satisfactory outcomes in the future.

Figure 4 shows the global scores on the three self-report inventories obtained by each participant and the group mean. Higher scores here mean better performance. Only one participant (participant 3) consistently rated performance better with his own devices. The other participants rated the performance of the test device greater than that for their own devices on at least one inventory. On average, the global scores were highest for the participants’ own devices by 6.3 percent, 5.2 percent, and 3 percent rating points for the IOI-HA, APHAB, and SSQ12, respectively. But according to t-tests for dependent variables, none of these differences reached significance (p > 0.37).

DISCUSSION

Relative to the setting of the participants’ own aids, higher gain settings were measured for a 65 dB SPL input in the test hearing aids across the lowest and highest frequencies. We are unable to determine how much of these settings resulted from leakage during threshold testing, the proprietary prescription that translates the measured threshold levels to the baseline hearing aid setting, or the fine-tuning performed immediately after self-fitting. However, given that several studies have demonstrated that hearing aid users during self-adjustments generally make little change to the baseline response shape (Ear Hear. 2008;29[2]:214; J Acoust Soc Am. 2008;124[3]:1668), a combination of the first two suggestions seems the most likely explanation.

We are also unable to determine the extent to which the participants may have further fine-tuned actual responses if given access to the CS Customizer app during the field trial. The extra gain resulted in the participants rating the test aids slightly, but significantly, louder than their own aids when listening to speech in quiet. Based on group data, though, there was no significant effect of hearing aid type on a range of commonly used outcome measures. The somewhat flatter gain/frequency response selected in the test device may have caused some upward spread of masking that affected speech-in-noise performance. The difference in SRT50 values approached but did not reach significance. Participants who produced the greatest difference in SRT50 values presented the greatest rms difference between the coupler responses obtained for the two devices.

The lower benefit score consistently reported for the test devices by participant 3 may be explained by his dissatisfaction with the ear tips. During the fitting, he expressed disappointment in the inability to transfer the open domes from his own hearing aids to the test devices and remarked that the closed domes of the test devices were inferior. Nonetheless, he voluntarily persevered with the study. We cannot exclude the possibility that his perception of the ear tips affected his view of the test aids, particularly as he compared the smallest difference in gain between devices and produced the same SRT50 values with both devices.

We also note that only people who performed the self-fitting process in an acceptable way and achieved an audiologist-approved outcome were invited to complete the field trial. That is, our preliminary conclusion regarding the efficacy of self-fitting hearing aids is predicated on the assumption that the initial setup instructions were accurately followed.

While limited, these data suggest that self-fitting aids may provide satisfactory benefit and performance to those who can manage the self-fitting process. Our findings show that at least one currently available self-fitting product is comparable to those measured with professionally dispensed hearing aids. A more extensive crossover study is clearly needed before a firm conclusion can be drawn. Making the self-fitting process simple, intuitive, and accessible to a wide range of hearing aid candidates is definitely a challenge, but we anticipate that the optimal implementation of the automated fitting processes, complemented by comprehensive instructional and support materials, could reduce barriers to access and ensure satisfactory outcomes in the future. It may even be possible to screen hearing aid candidates for the ability to self-fit. ①