Hearing better, feeling better: ReSound Key has a positive impact on patients' lives

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INTRODUCTION

Hearing aid users report multiple benefits from using their hearing aids – not just for their hearing but also for their social lives, general health and well-being[1,2,3]. In one survey of hearing aid users in the UK, 71% said they wished they had tried hearing aids sooner, because of the benefits they gained from their use[3]. Close loved ones of people with hearing loss, such as spouses or adult children, also notice the problems hearing loss causes their loved one and that hearing aids can help[1,4]. Despite this, people with treatable hearing loss are still waiting an average of nine years before trying hearing aids[5]. The cost of hearing aids is certainly one barrier that contributes to this problem[6].

At ReSound, we believe everyone deserves great hearing. ReSound Key is the newest addition to our full portfolio of hearing solutions. Like all our hearing aids, ReSound Key is designed on the ReSound Organic Hearing philosophy, which is inspired by natural hearing processes and listening behavior. ReSound Key can be fit with Natural Directionality II, a unique way to apply directional microphone technology using a binaural hearing strategy. Patients benefit from an improved signal-to-noise ratio (SNR) while maintaining awareness of sounds around them, in nearly any listening situation, in a way that leverages the ways we naturally listen[7].

A field study was conducted to examine the various benefits that ReSound Key hearing aids can have in the daily lives of patients with hearing loss. Field studies of hearing aid use – as opposed to laboratory measurements of a specific algorithm or feature – can be particularly helpful for expressing the benefits of hearing aids in a realistic context that a current or potential user of hearing aids, and their family, can relate to and understand. The study participants rated their hearing, mood, stress and fatigue levels on a daily basis using a methodology called ecological momentary assessment (EMA). The advantage of EMA for a field study of this nature meant that participants could report their experiences with ReSound Key in the moment and place it occurred – reducing memory errors from trying to remember a past event or listening environment[8]. Today's smartphone and app technology make collecting this EMA data more streamlined and practical than ever.

Specific questions we wanted to examine in this study were:

1. How well did the participants hear and feel with ReSound Key? Was there a relationship between hearing and daily well-being?
2. How did participants rate ReSound Key hearing aids and Natural Directionality II when they evaluated them in their everyday listening situations?
3. Did the spouses of the participants have any insight into how the participants heard?

METHODS

Twenty experienced adult users of hearing aids were recruited from an existing database of GN Hearing study participants in Ballerup, Denmark. Participants were fitted with binaural ReSound Linx Quattro receiver-in-the-ear (RIE) hearing aids that were adjusted to be equivalent to ReSound Key (see Table 1). This was done because ReSound Key was not yet available at the time of the study.

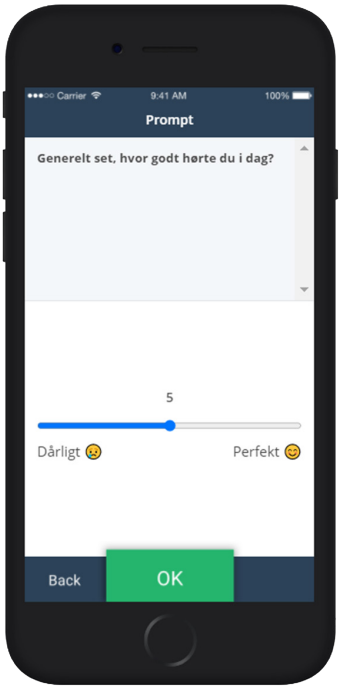
All participants were fitted with high power (HP) receivers, to mimic the receiver bandwidth of ReSound Key.
All participants fitted with one program (All Around) using Natural Directionality II.
Advanced features (e.g., DFS Ultra II) were adjusted to match ReSound Key defaults.

Table 1: ReSound Linx Quattro RIE devices were used in the study. These adjustments were made to recreate settings for ReSound Key.

The Audiogram+ fitting rationale was used for the fitting and gain fine tuning was allowed if requested by the participant. One program (All Around) was fitted for all participants using the Natural Directionality II microphone mode[7], which they used exclusively for the at-home trial. The participants downloaded a smartphone app called RealLife Exp (Life Data, LLC) in order to receive and complete EMA surveys. All the participants owned their own

smartphone and felt comfortable using the app after a brief in-person demo with the study audiologist. Two types of surveys were sent to the participants each day. One survey called "End of day" was sent each evening at 8pm. Participants were asked to rate their hearing, listening effort, mood and feelings of stress and fatigue over the course of the day. The second survey "Your hearing right now" asked for similar ratings but also asked which listening situation the participant was in at the time the survey was completed. This survey was sent randomly one time per day any time between 9am-7pm.

The survey ratings were presented as a 0-10 scale, where 0 reflected a very poor or negative score and 10 represented a perfect score. The survey items and anchor words were written in English, then translated by a bilingual speaker of English and Danish and checked for accuracy and naturalness by a native Danish speaker.
The actual user interface for the survey, with an example



question and rating slider, are shown in Figure 1.

Figure 1: Screenshot of user interface of RealLife Exp app survey. All survey items used the 0-10 scale, with 0 = negative/poor response and 10 = positive response. The emoji icons were used to reinforce this, along with anchor words specific to each item. The participant selected a rating using their finger to move the slider to the intended number. The survey question in English reads "In general, how well did you hear today?" with "Very poor" and "Perfect" as the rating anchors. (LifeData, LLC.).

All participants were recruited in June, 2020 and completed the study by August, 2020. Procedures to ensure participant and tester safety were implemented in light of the ongoing COVID-19 pandemic. The participants were reimbursed for travel costs to the research site.

RESULTS

Participants

One study participant dropped out after the first visit due to an ear infection. Data for this participant is excluded. Ten male and nine female participants remained, with a mean age of 70 years (stdev = 8.6). Eighteen of the 19 participants in the study were experienced bilateral hearing aid users, with a mean experience of 9.4 years (stdev = 7.8). The remaining participant had previous experience using hearing aids in clinical trials.

Each participant presented with symmetric, sensorineural hearing loss and were candidates for the HP receivers used in the trial. On average, the participants had normal-to-near normal hearing below 500 Hz, sloping to a severe, symmetric sensorineural hearing loss in the high frequencies.

ReSound Key usage and datalogging

The participants wore ReSound Key for an average of 28 days (stdev = 2.5). The participants were very consistent in their hearing aid use, according to both their subjective reports and the datalogging collected from the hearing aids at the end of the study.

Participants were asked "Did you wear your hearing aids today (for any amount of time)?" on the "End of day" survey. 94% of completed surveys indicated yes. Nearly all participants who said yes to hearing aid use (90.5%) used the hearing aids for at least 80% of the day.

Datalogging was collected from the hearing aids of 15 participants. There was a mean use time of 12.7 and 13.4 hours per day for the right and left devices, respectively. In addition, datalogging gives information on each participant's patterns of usage. By analyzing use time in various defined acoustic environments, the Smart Fit fitting software makes observations about how the participant has been using their hearing aids. These observations are listed in Table 2. All 15 participants for whom datalogging could be read show consistent usage, while all but one participant used both hearing aids equally. Note that seven out of 15 participants experienced a variety of listening environments according to the datalogging, which will be examined in the next section.

	Hearing aids used regularly	Encountered a variety of environments	Used both hearing aids equally
Number of observations	15	7	14

Table 2: Number of observations from datalog that describe each participant's hearing aid usage behaviors. N = 15.

The variety of listening environments experienced by the participants were documented in the "Your hearing

right now" daily surveys. On this survey, participants had to report one location ("Where are you") and one activity ("What are you doing") that represented their current listening situation during survey completion. The percent of time spent in each environment and activity are displayed in Figures 2 and 3. Note that there is overlap between environment and activity, since one of each were reported on a single survey. The responses to the environment and activity each add up to 100%. These figures represent data from 532 completed "right now" surveys.

WHERE ARE YOU RIGHT NOW?

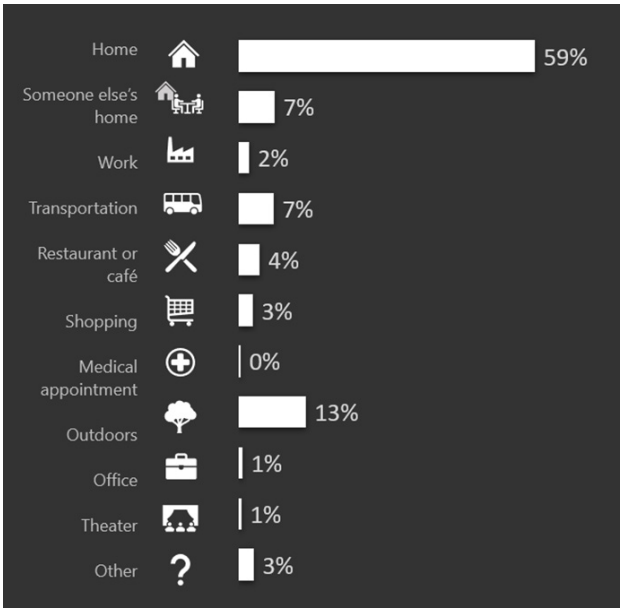


Figure 2: Percentage of time spent in listening environments as reported by the participants on the "Your hearing right now" survey. N = 532 completed surveys.

WHAT ARE YOU DOING RIGHT NOW?

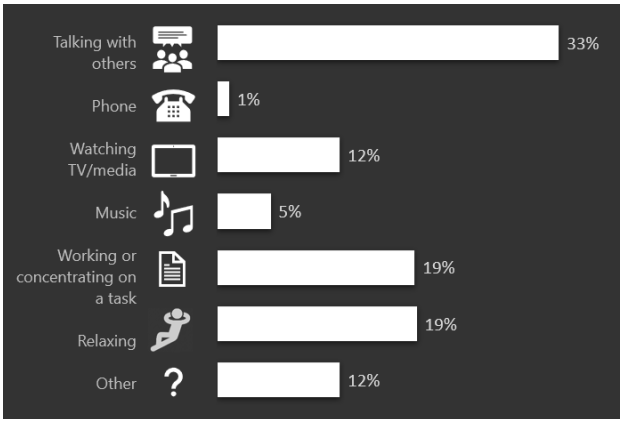


Figure 3: Percentage of time spent in different activities as reported by the participants on the "Your hearing right now" survey. N = 532 completed surveys.

The survey responses suggest much of the participants' time was spent at home, with a response rate of nearly 60%. There was a fair amount of variation in listening environments, with more noisy, dynamic environments representing over one fourth (27%) of the reported situations (transportation, shopping, restaurant/café, outdoors). Talking with other people occurred one third (33%) of the time and was the single activity reported the most. Eighteen percent of time was spent using electronics – listening to music, media or talking on the phone. A large amount of time (38%) was also spent in quiet, solitary situations, like relaxing and concentrating on a task.

While it is not possible to validate the datalogging trends regarding listening environments in a detailed way, the results from the survey complement the observations on listening environments. Both methods show a greater concentration of quieter situations observed, along with a substantial proportion of noisy, more complex environments.

Survey responses

Over the course of the trial, two surveys were sent per day to each participant, for a total of 1,324 survey requests. Over 1,000 of these surveys were completed. Table 3 outlines the response rates for the daily surveys.

	"End of day" (daily at 8PM)		"Your hearing right now" (once daily between 9AM-7PM)	
	N	%	N	%
Total surveys sent	662	100	662	100
Surveys partially completed	567	86%	552	83%
Surveys completed	518	78%	515	78%

Table 3: Response rates for the "End of day" survey and the "Your hearing right now" survey through the entire trial period.

IN THIS LISTENING SITUATION...

Figure 4: Display of example survey data for the study.

Figure 4 displays example survey data collected from the participants. The average response for each survey question is reported as the median, which is the number located inside each circle. The median will always be between zero and ten, because that is the full range of possible responses for each survey question. The grey bars extending from each circle represent variability in responses via the interquartile range. The bars contain the middle 50% of all responses – from the lower 25% through the top 75%. The further from the median the bars extend, the greater the variability in individual responses on that survey question.

Green circles represent responses to the survey question while ReSound Key hearing aids were used, while red circles represent responses when no hearing aids were used.

How are you hearing?

First and foremost, we wanted to measure how well the participants felt they heard while using ReSound Key. Survey responses when no hearing aids were worn provided a baseline comparison for the responses reflecting hearing aid use. As we already know, ReSound Key use was very consistent, so sample sizes for unaided surveys are

much smaller compared to the aided surveys. Statistical analyses using a two-tailed Mann Whitney U test were completed on the survey items when there were aided and unaided responses to compare.

Participants answered the following questions on the "Your hearing right now" survey, shown in Table 4. The left column reflects questions asked on every survey, while the right column reflects questions presented if the participant wore ReSound Key. ReSound Key was rated on how helpful the participants found it to be, on sound quality, how well the participants could locate the direction(s) of sounds and their satisfaction. These questions were inspired by an existing outcome validation questionnaire[9]. Data from this survey allowed for analyses of hearing abilities and hearing aid performance specific to each listening situation.

Where are you?	How much are your hearing aids helping you?
What are you doing?	How would you rate the sound quality?
How many people are you talking with?	How well can you tell which direction(s) sounds are coming from?
How much background noise is there?	How satisfied are you with your hearing aids?
How is your hearing?	
How much listening effort are you using to hear?	
How worried or upset are you with your hearing?	

Table 4: List of questions on "Your hearing right now" daily survey. Questions in the left column represent questions always presented; questions in the right column were only presented if the participant reported using ReSound Key.

Three listening situations stood out as most interesting to share. First, the participants' experiences while talking with other people. Then results for two of the more dynamic environments – restaurant/café and outdoors. While much of the participants' time was spent at home, results from the survey suggest the participants experienced high rates of success with ReSound Key and their hearing abilities overall at home. This is certainly encouraging, especially for those patients who spend a lot of time at home, but those results are not unexpected and not discussed here, in favor of more challenging and diverse situations.

Recall that participants reported one of many possible listening situations on each survey, therefore the number of completed surveys for each environment are not equal. The survey sample size (N) for each listening situation are reported in each section.

Talking with other people

One of the most important listening activities people participate in are conversations with other people. This section represents 173 completed surveys where "talking with other people" was reported as the answer to "What are you doing?". 163 of these surveys were answered while using ReSound Key (94%) and ten surveys with no hearing aids (6%).

Figure 5 summarizes the listening environments reported by the participants when they were talking with others. A variety of environments are represented for "talking with other people," with most people at home (43%) and a nearly equal number of people at someone else's house (14%), at a restaurant/café (12%), outdoors (13%) or using transportation (9%).

TALKING WITH OTHER PEOPLE

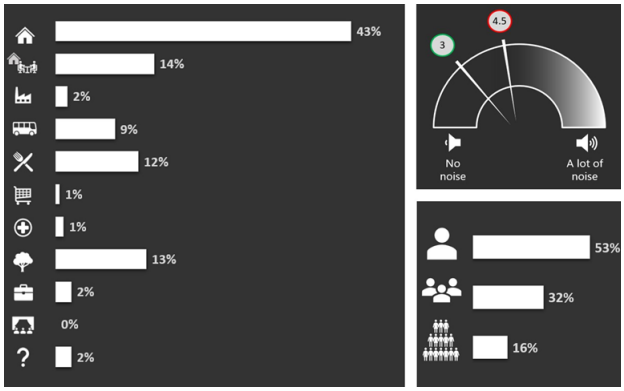


Figure 5: Summary of listening situations when participants reported they were talking with other people. From clockwise: Listening activities while in a restaurant; median ratings of background noise level when hearing aids were worn (green circle) and not worn (red circle); reported number of conversation partners.

Participants reported just over one half of the conversations they participated in were with one other person (53%), while 32% occurred with a small group (2-4 people) and 16% with a large group (5+ people). The median rating of background noise was slightly lower for the aided surveys (3/10) than the unaided responses (4.5/10). However, there was no statistical difference between the median noise rating across hearing aid condition ($p > 0.05$) This suggests that the background noise when talking with others was relatively similar when hearing aids were and were not worn.

We see clear differences in ratings for ReSound Key versus unaided for how well the participants heard, how much listening effort they needed to use, and how worried or upset they felt about their hearing (Figure 6). The median ratings are higher by 3.5-4 points on each item when ReSound Key was used. This positive effect of hearing aid use includes all situations where the participants talked with other people, as summarized in Figure 5. The difference between aided and unaided ratings on all three items were statistically significant ($p < 0.05$).

WHEN TALKING WITH OTHER PEOPLE...

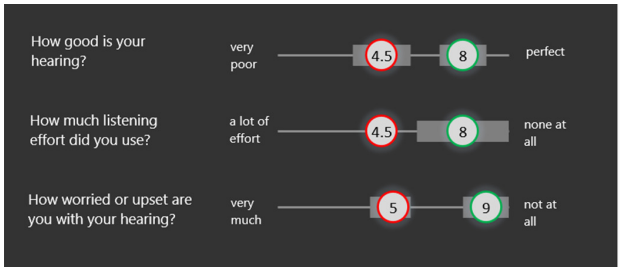


Figure 6: Median ratings for each "right now" survey item. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N =163). Red represents responses with no hearing aids (N = 10).

Another interesting observation is the range of responses obtained while participants wore ReSound Key. The interquartile range of all responses for "How good is your hearing?" and "How worried or upset are you with your hearing?" fell within one point above and below the median ratings – meaning half of the participants reported their hearing – and how they felt about their hearing - as at least a 7/10. Listening effort was more likely to vary across the participants.

The range of responses on all items for unaided listening were much more concentrated around the median ratings. This means the median scores, centered around 4.5/10 and 5/10, reflect the range of responses even better than those reflecting the aided scores. Note that five different participants contributed to the ten unaided surveys, so the low amount in variability is not simply explained by the same participant or two representing all the unaided surveys.

Median ratings specific to ReSound Key are displayed in Figure 7. Overall, the ratings for ReSound Key were very positive. Median scores were 8/10 for how much the hearing aids helped, sound quality and satisfaction, and 9/10 for telling the direction(s) of sounds. The interquartile range for each item demonstrates that 50% of all participant responses fell between scores of 7-10.

RESOUND KEY RATINGS WHEN TALKING WITH OTHERS

Figure 7: Median ratings for each "right now" survey item relating to ReSound Key. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 163).

Restaurant, café, or bar

There were 22 completed surveys representing experiences in restaurants, cafés, or bars. The listening situation summary shows a high amount of background noise (7/10) and nearly all activity (95%) devoted to talking with other people (Figure 8). Group conversations were more likely in this environment, with one fourth (27%) of conversations occurring in small groups, and one third (32%) in large groups of people. This demonstrates how restaurants can be a very challenging situation! There is not only a lot of competing noise and distractions, but there is also the added pressure of participating in a social event with one or many people.

RESTAURANT, CAFÉ, OR BAR

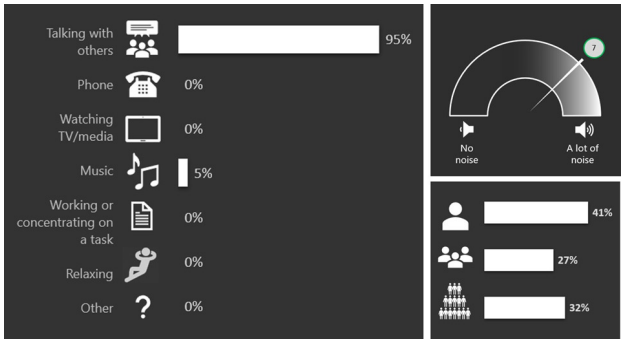


Figure 8: Summary of listening situations when participants reported they were in a restaurant, café, or bar. From clockwise: Listening activities reported in this environment; median ratings of background noise level when hearing aids were worn (green circle); reported number of conversation partners. Note that hearing aids were always worn in this environment so there is no unaided data to share.

Figure 9 displays the median ratings for hearing ability, listening effort and feelings about hearing while in a restaurant, café or bar. There were no unaided comparisons of hearing abilities since hearing aids were worn 100% of the time.

WHILE AT A RESTAURANT, CAFÉ, OR BAR…

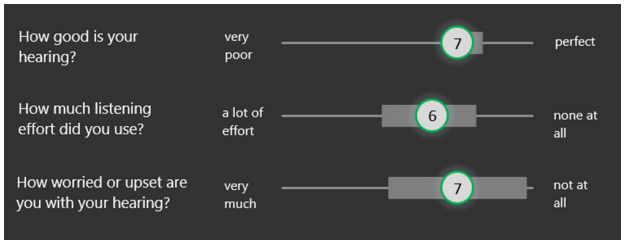


Figure 9: Median ratings for each "right now" survey item. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 22). Note that hearing aids were always worn in this environment so there is no unaided data to share.

Overall, the hearing ability ratings are lower for this environment, which is to be expected for such a challenging situation. The median rating of 7/10 for hearing ability, while lower than the median ratings for other environments, did have many ratings concentrated around this median. 50% of the participants felt their hearing fell between a 7 or 8 out of 10, which is quite encouraging considering background noise was rated a high 7/10. Ratings for the participants' feelings of upset or worry and listening effort demonstrated similar median scores (7/10 and 6/10, respectively). There was more variation in the participants' ratings of listening effort and negative feelings regarding hearing. This is also not unexpected, because the participants likely had to work harder to hear and cope in this situation.

The participants reported wearing ReSound Key every single time they were in a restaurant, café or bar and completed a survey. Note that the aided ratings for this difficult environment are better than the unaided ratings for presumably less challenging environments where the participants were talking with others (see Figure 6). This certainly suggests that if the participants had attempted the restaurant, café or bar situations unaided, their ratings would likely have been very poor. This is one clue that

the hearing aids were considered essential, and not just beneficial, in this type of situation.

Figure 10 shows that ReSound Key was rated positively by the participants, even as they worked harder to hear. The highest median ratings were obtained for how much help the participants felt they received from ReSound Key, as well as how satisfied they were, with an 8/10 median rating. Sound quality and telling the direction(s) of sound were slightly lower at 7/10. In such a noisy situation where sounds were likely shifting around and coming from many places, it isn't unexpected that both sound quality and sound localization would not be considered perfect – but these dimensions would also be less important as overall hearing, since conversation in noise would be the main listening goal.

RESOUND KEY RATINGS WHEN IN A RESTAURANT, CAFÉ, OR BAR

Figure 10: Median ratings for each "right now" survey item relating to ReSound Key. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 22).

Outdoors

One of the more common listening environments reported by the participants was time spent outdoors. This made sense since the study was completed in the summertime. A total of 71 surveys were completed for outdoors, with 66 surveys completed with ReSound Key and five surveys with no hearing aids.

The outdoors can be a challenging listening situation for people with hearing loss, even while using hearing aids. It involves any number of activities occurring in open space, often with the addition of wind noise. Sounds often occur all around the listener, which are important not just for hearing, but also for awareness and safety.

The results from Figure 11 reflect the variable nature of time spent outside. Nearly one third of the time spent outside was talking with others, and even more time (43%) spent concentrating on a task or just relaxing. One fourth of the time (25%) was spent doing "other" activities, which may represent being active though we cannot say for sure. Background noise appeared to be relatively low, with median ratings of 3 and 4 for aided and unaided responses, respectively. Once again, the differences in background noise ratings were not statistically significant for aided and unaided surveys ($p>0.05$). The participants spent nearly half of their time outdoors talking one-on-one with someone else (46%), and 30% of the time speaking in groups. This leaves 24% of their time not speaking to anyone.

OUTDOORS

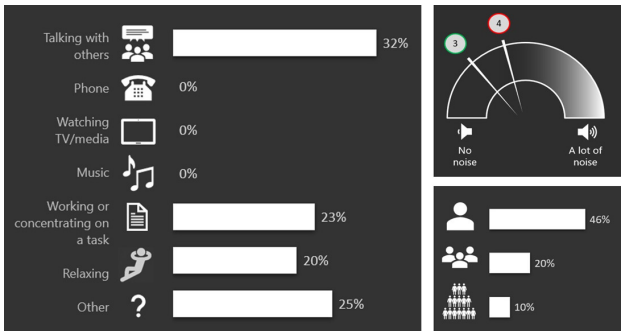


Figure 11: Summary of listening situations when participants reported they were outdoors. From clockwise: Listening environments where conversations took place; median ratings of background noise level when hearing aids were worn (green circle) and not worn (red circle); reported number of conversation partners.

The median ratings for hearing outdoors with and without hearing aids are displayed in Figure 12. Median ratings of hearing and listening effort were 8/10, while the median rating of how worried or upset the participants felt about their hearing was a perfect 10. Without hearing aids, the median ratings were all 5/10. The difference in ratings between aided and unaided conditions were statistically significant for all three survey items ($p<0.05$). The interquartile range for the unaided ratings give us a better idea of how the participants performed without hearing aids. The responses for how well they heard ranged from 4 to 7 - somewhat similar to the lower range of responses for aided hearing. On the other hand, listening effort was rated as less favorable every time hearing aids were not worn, no matter how well they may have heard.

WHILE OUTDOORS...

Figure 12: Median ratings for each "right now" survey item. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 66). Red represents responses with no hearing aids (N = 5).

The ReSound Key ratings, shown in Figure 13, differ a bit when compared to ratings for the restaurant environment. Outdoors, we see that ratings of sound quality and telling the direction(s) of sound are rated higher than they were for restaurants. This likely reflects the more open and diffuse nature of outdoors, compared to the noisy and closed-in situations typically found in restaurants. These ratings suggest that the participants found ReSound Key, and the Natural Directionality II setting, to contribute to a clear and natural sound. The median rating of 9 out of 10 for localizing sounds is especially encouraging here, since users need to be able to tell where sounds originate from outdoors, where hearing sounds like traffic or people approaching from behind can become a safety issue.

RESOUND KEY RATINGS WHEN OUTDOORS

Figure 13: Median ratings for each "right now" survey item relating to ReSound Key. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 66).

How are you feeling?

This study was designed to track not just the hearing experiences of the participants, but also to gain a better understanding of their emotional well-being. Each evening, the participants received the "End of day" survey, which asked similar hearing-related questions as the "Your hearing right now" survey, but also added additional questions relating to their overall mood, stress and fatigue at the end of the day. An additional question examined a possible reduction in desired activities caused by hearing loss. The questions from this survey are outlined in Table 5.

Overall, how well did you hear today?	How much did your hearing aids help you?
How well does your spouse think you heard?	How would you rate the sound quality?
Overall, did you have to use a lot of effort to hear?	How well could you tell which direction(s) sounds are coming from?
How do you feel about how you heard today?	How satisfied were you with your hearing aids?
How tired are you at the end of today?	
How stressed are you at the end of today?	
How much did your hearing prevent you from doing the things you wanted to do today?	

Table 5: List of questions on "End of day" daily survey. Questions in the left column represent questions always presented; questions in the right column were only presented if the participant reported using ReSound Key.

Ratings for the "End of day" survey are displayed in Figure 14. There were a total of 538 surveys, with 502 surveys completed on days where ReSound Key was worn and 32 surveys completed for days without hearing aids. The overall sample size for the "End of day" survey appears much higher than for "Your hearing right now" because the "End of day" survey is not divided by listening situation.

OVERALL TODAY...

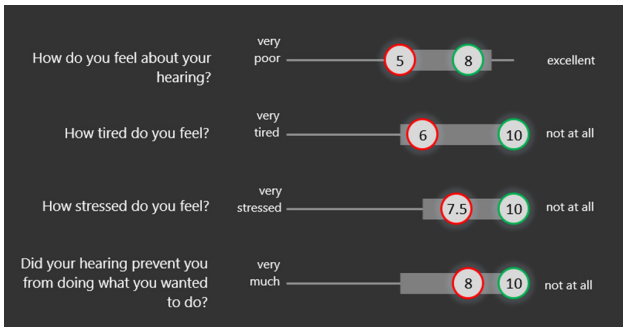


Figure 14: Median ratings for "end of day" survey items relating to emotional well-being. Error bars display interquartile range (the middle range of responses from 25-75%). Green represents responses when hearing aids were worn (N = 506). Red represents responses with no hearing aids (N = 32).

There is a difference in median ratings for surveys completed when participants wore ReSound Key versus no hearing aids. The difference isn't as dramatic as the items from the previous section that relate directly to hearing – but even though we aren't asking about how well they heard in these items, we still see differences based on hearing aid use, and the differences on each item between aided and unaided are statiscially significant ($p<0.05$). On days when ReSound Key hearing aids were worn, the participants rated their feelings about their hearing as a median 8/10 and their feelings of stress, fatigue and handicap as a median score of 10/10, meaning no negative impact from these items at all. Median scores on unaided surveys are generally lower than those with hearing aids, especially ratings for "How do you feel about how you heard?" and "How tired do you feel?".

One large difference between aided and unaided scores on this survey were the interquartile ranges. For the responses obtained with ReSound Key, there is very little variation from the median rating. For each survey item displayed in Figure 14, 50% of all participant responses fell within 2 points of the median. In order to account for 50% of the responses obtained without hearing aids, we need as many as 5 points away from the median scores. We can expect more variation in the unaided responses, because the sample size is smaller than those for the aided responses. However, note that we had a similar issue with sample size for ratings of hearing in the previous section, and we did not see such dramatic differences in interquartile range across hearing aid condition. This suggests that hearing aid use may be associated with more positive emotional state at the end of the day, with more consistency in that experience than no hearing aids.

The question "Did your hearing prevent you from doing what you wanted to do today?" had the least difference in median ratings between the aided and unaided conditions. This may lead one to believe ReSound Key was not impactful for this dimension. However, when we observe the relative frequency of all responses for each 0-10 rating (i.e., a histogram), we get a better understanding of how ReSound Key may have influenced the results (Figure 15).

HISTOGRAM OF RESPONSES TO "DID YOUR HEARING PREVENT YOU FROM DOING WHAT YOU WANTED TO DO TODAY?"

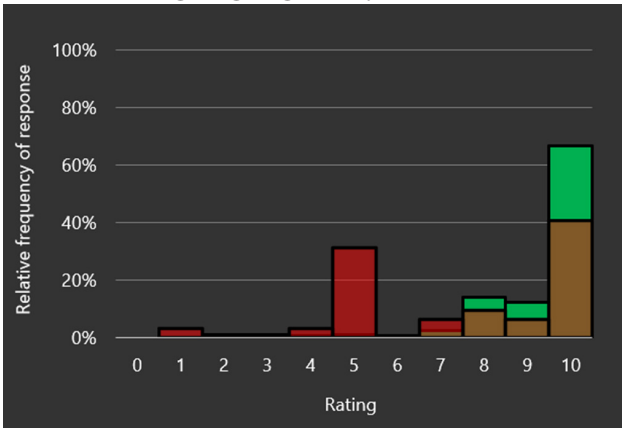


Figure 15: Relative frequency of all aided and unaided responses to the survey question "Did your hearing prevent you from doing what you wanted to today?". Green bars represent proportion of responses where ReSound Key was worn (N =506). Red bars represent proportion responses when no hearing aids were worn (N = 32). The red-brown bars represent responses that overlapped across aided and unaided conditions.

First, we see a high proportion of responses as a perfect 10 in both the ReSound Key condition (67%) and no hearing aids (41%). But once we observe ratings lower than 10, differences across the conditions become more apparent. The ReSound Key responses are almost entirely concentrated between 8-10, with only 2.5% of the ratings observed at 7. The only responses to the question at 5 or below occurred for surveys where participants did not wear hearing aids. Ratings between 0-5 accounted for 37% of the total unaided responses. This demonstrates that ReSound Key likely had with a positive impact on this dimension of hearing handicap, even though the average data appeared more similar.

We can also examine the relationship between the ratings for emotional state at the end of the day with the ratings related to hearing with ReSound Key. Figure 16 shows the correlation (Spearman's rho) between the survey question "How do you feel about your hearing?" and the other questions on the same survey. The correlation can range anywhere from 0 (no correlation) to 1 (perfect positive correlation), with a higher value suggesting a stronger relationship between "How do you feel about your hearing?" and the other survey items. All the correlation scores are statistically significant ($p<0.05$). The relationships between the survey items are positive, meaning as the ratings for feelings regarding hearing improved, ratings for the other survey items also improved

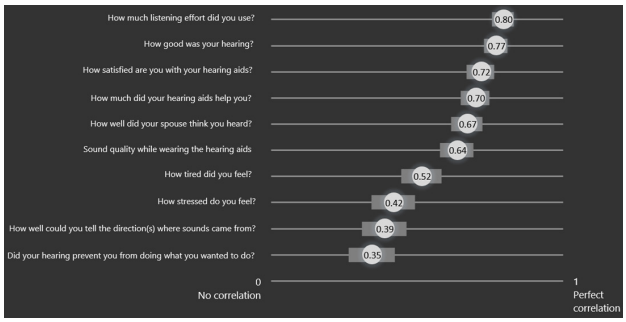


Figure 16: Correlation coefficients (Spearman's rho) for the question "How do you feel about your hearing?" and the additional items from the same "End of day" surveys (N = 506). Only responses with ReSound Key are included. Error bars denote 95% confidence intervals. Correlations were statistically significant for all items ($p<0.05$).

The ratings for all the items on the "End of day" survey had a significant positive correlation with the question "How do you feel about your hearing?". The items with a direct relationship to hearing and hearing aid performance, such as "How well did you hear today?", "How much did the hearing aids help you?" and "How satisfied are you with the hearing aids?" tended to demonstrate the highest correlation. This demonstrates how feelings regarding a person's hearing abilities improves as their hearing improves, in this case with the use of hearing aids. While the correlation to other ratings of participant well-being, such as "How tired did you feel?", aren't as high, they still reflect a significant relationship that may be less obvious to loved ones of a person with hearing loss or even HCPs. Factors relating to feelings of well-being, and even spouses' perceptions of how well they think the participant is hearing, all had some impact on the feelings participants reported each day.

Hearing from the spouses' point of view

The spouses of the study participants were asked to participate in the daily "End of survey" as well. One question "How well does your spouse think you heard?" required the spouse's input regarding the study participant's hearing. The goal was to determine if the spouses of the participants had any insight into the hearing abilities of the participants, and if there were any significant differences in these ratings between the participants and their spouses.

It appears that the spouses were, in fact, quite in tune with the hearing abilities of the participants. The median scores were identical across participant ratings for "How well did you hear today?" and spouse ratings of "How well did your spouse think you heard?". On days when ReSound Key hearing aids were used, both participants and spouses rated the participants' hearing as 8/10. On days where no hearing aids were used, hearing was rated as 5/10 by both groups. Clearly, spouses of the study participants noticed how well – or not well – their loved one was able to hear throughout the day, and that ReSound Key had a positive impact.

SUMMARY

A field study was conducted to measure the impact of ReSound Key on various outcomes relating to patients' hearing and well-being. The methodology of using daily surveys sent via smartphone app appeared to be a success, with a high response rate and ease of use.

Results support that the participants found ReSound Key to be helpful in a variety of listening situations, and ratings of sound quality, localization abilities and satisfaction were generally positive. The participants rated their hearing, listening effort and feelings about their hearing abilities as higher overall when using ReSound Key versus no hearing aids. Specifically, we found:

1. **How well did the participants hear and feel with ReSound Key? Was there a relationship between hearing and well-being?**
   Median ratings for both hearing-related and feeling-related questions were more positive when participants wore ReSound Key. There was an observed relationship between hearing and feeling in this study, with the strongest correlation to feelings at the end of the day observed with ratings for hearing, listening effort and hearing aid satisfaction.

2. **How did participants rate ReSound Key hearing aids and Natural Directionality II when they evaluated them in their everyday listening situations?**
   The hearing aids were generally rated positively on all four measured dimensions of how much help they provided, sound quality and telling the direction(s) of sounds and satisfaction. The median scores did differ based on listening situation, which would be expected as the acoustics and listening goals of the participants differ depending on the situation. But even for the toughest situations, where hearing was rated lower and more listening effort was needed, ReSound Key still received high median ratings for how they improved the participants' hearing abilities.

3. **Did the spouses of the participants have any insight into how the participants heard?**
   Yes, the spouses of the study participants rated the participant's hearing over the course of each day similarly to the participants themselves. Median scores for hearing were identical for both groups, on days when ReSound Key were used and not used. The spouses were able to recognize how their hearing-impaired spouses' hearing improved when ReSound Key was used in the study.

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