



The Hearables Report 2020-2025

Since I first coined the word “Hearables” in 2013, the market has become the fastest growing consumer technology sector we have ever seen. Far from slowing down, that growth is continuing, providing massive opportunities for innovation in the sector as new entrants challenge Apple’s dominance.

Six years on, this report looks at the current status of the hearables market and predicts where it will go in the coming six years.

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The Hearables Market 2020 - 2025

Have you noticed anyone's ears today? That may be one of the strangest questions ever to open a market report, but I suspect the answer is yes. When I wrote the first version of this report [1] back at the end of 2016 the answer would almost certainly have been no, unless it was some particularly striking pair of earrings. Yet in the space of less than four years, around a hundred million pairs of earbuds have been sold, Wherever you are in the world, you've probably noticed a pair of white AirPods – the visible sign of the way in which Apple has managed to dominate the market. In the last few months, that almost total ownership has seen some competition, with the appearance of other colours and shapes adorning people's ears, but they easily remain the market leader. That may be about to change. In the first few days of 2020 I'm seeing other earbuds nestling in ears, suggesting that the first real challenge to Apple's position is occurring.

At the end of 2016, the prediction of a market value of \$6.7 billion for earbuds in 2019 seemed optimistic, but events have overtaken that. It currently looks as if we will see sales double that, at just over \$13 billion for 2019, which makes them the fastest growing consumer market product ever. In terms of growth, AirPods put the iPhone to shame. The question now is "what comes next"? In this report I look at what the prospects are for the next five years. We are only just at the start of the hearables market. By 2025 I expect it to have grown in size to a value of \$80 billion. I am aware that number goes beyond what others may anticipate, but we have barely seen the start of what hearables can accomplish.

The journey so far

The first few years of the hearables journey was largely driven by innovation within crowdfunded companies. Starting with Earin and Bragi, over forty companies managed to acquire over fifty million dollars from crowdfunding supporters to pursue their dreams. Bragi's Dash earbuds, launched in February 2014, rapidly became the poster child of hearables, offering to pack in almost every sensor and feature that their designers could think of. It says much of the skill of the company that they actually managed to deliver a product. Like almost every other startup they learnt the lesson that making such small audio hardware is incredibly difficult. Having succeeded in getting the Dash out, they also discovered the difficulty in building a market, where brand can be critically important. Although Bragi survives today, it is no longer as a manufacturer of hardware, but as a software developer and supplier. In that sense they have fared better than most of the hearables startups, who ran out of cash, in some cases before delivering a product. Despite that fate, they left a legacy of innovation which has given massive impetus to the industry. In many cases, the expertise they developed has not been lost. Many members of Bragi and Doppler's design team are behind the recent hearables from major manufacturers that have entered the market.

The AirPod phenomenon

When they first appeared, the media reaction to Apple's AirPods was muted. Their shape was compared to an electric toothbrush and much fun was had at the prospect of them falling out (Conan's spoof advert of the AirPod dog is still worth watching [2]). The biggest criticism was that they looked too geeky and nobody would wear them. How wrong that was. It's rare to go out

nowadays and not see them being worn. Wherever I am in the world I expect to see people wearing AirPods. That is reflected in stunning sales figures, which suggests a CAGR over their three year life of around 50%, which is phenomenal and shows little evidence of faltering.

Compared with the first tranche of crowdfunded hearables, the specification of the AirPods looks rather thin. If users really did buy products on the basis of technical features, then the AirPods would have failed. But, more than possibly the case with any other product, users have flocked to the AirPods because they do one thing and do it very well. Apple have eschewed adding a myriad of biometric sensors and concentrated on delivering an audio experience which is as good as a wired earbud with the convenience of wireless.

Getting that right is incredibly difficult and I'll explain some of the technical reasons later. In order to create that level of performance, Apple needed to design their own Bluetooth® chip, extend the Bluetooth protocols and develop an advanced cloud-based method of pairing. Achieving that will have cost them many tens of millions of dollars and was probably a project that took the best part of five years. I suspect that it was signed off predominantly because of the need to have an iconic Apple branded wireless headset to complement the demise of the 3.5mm audio jack on the iPhone 7, rather than viewing them as a major revenue stream. Few involved in the project probably had any idea of the overwhelming success the product would have. I do wonder if a second version was even considered at the outset, or whether the assumption was that earbuds would be catered for by Beats? We will probably never know the answer to that now. The irony is that Apple is almost certainly now outselling Beats, making it the largest supplier of consumer audio headsets.

Apple was certainly not slow at seeing the potential. The AirPod 2 brought wireless charging and the more recent AirPod PROs added noise cancellation. What is fascinating is the single-mindedness Apple is showing in focusing purely on convenience and audio quality. If we compare the evolution of the Apple watch, which did not have the overnight success of AirPods, we have seen far more technical innovation with each release as Apple has sought the killer app. With AirPods they have not needed to find it – it is already there as the *raison d'être* of an earbud. It's music. It's a lesson that all of Apple's competitors need to learn.

At some point I do expect to see Apple move beyond a pure audio experience for AirPods, but that may take longer than I previously envisaged. In the meantime, they are setting a very high bar for anyone else attempting to play in the market.

Sizing the Market

It's always difficult to predict sales in a new market, especially where there is little historical background. Hearables is almost certainly the fastest growing consumer produce sector we have ever seen, growing from first shipments of a few hundred thousand pairs of earbuds in 2016 to almost one hundred million during 2019. To try and assess what will happen in the next six years we need to look at why hearables had proven to be so compelling and use those factors to gauge their potential. To do that, the most effective approach is not to look at the technology, or even what manufacturers think the market may need (they have a habit of getting it wrong), but to look at what consumers are already doing and how we can provide products which allow them to do that more effectively and more conveniently. As far as hearables are concerned there are two main trends that

we need to consider – the slowing purchase cycle for smartphones, as consumers find little reason to upgrade, and the growth of audio streaming.

The aftermath of peak smartphone

Although I've always wondered why anyone pays more than \$100 for a phone (what do you get for the extra \$500 - \$1,000?), I'm obviously an insignificant outlier, as the smartphone industry has blossomed ever since Apple gave us the iPhone. At least it did until the end of 2016 when global shipments began to fall [3].

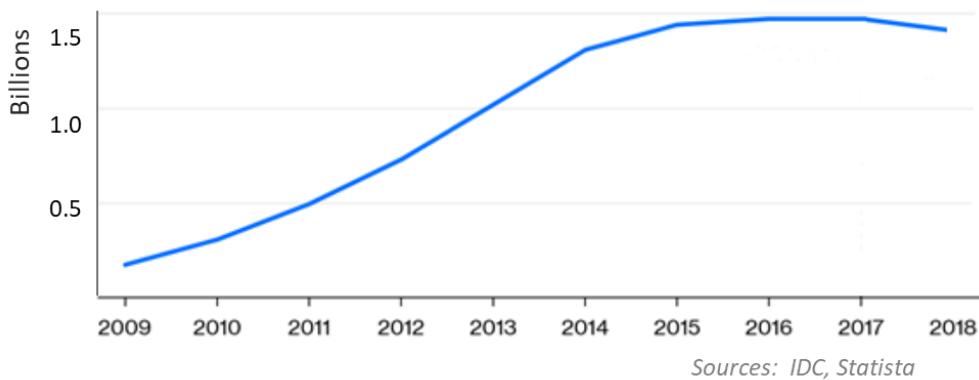


Figure 1. Annual global smartphone shipments have peaked

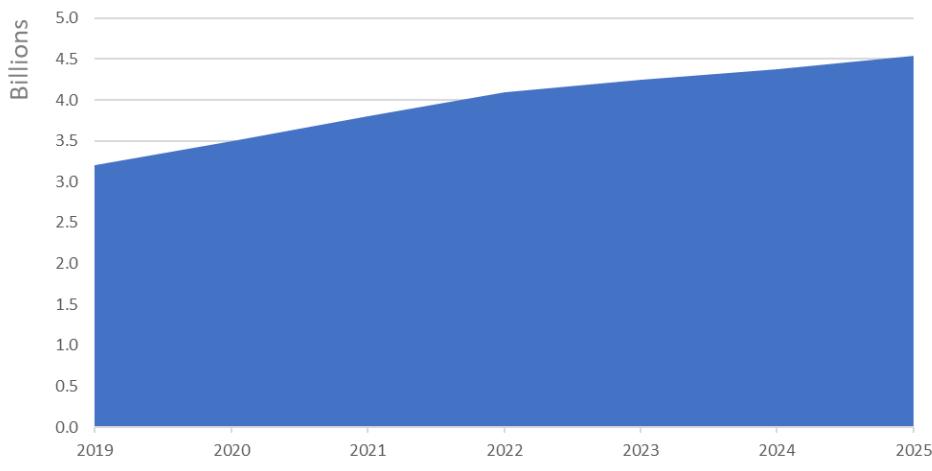
The issue facing manufacturers was that each incremental step seemed less significant to the majority of users, who found less reason to upgrade to each year's new model. That fall has continued and there is little evidence that it will change. Announcements of new models are now barely newsworthy. That's bad news for manufacturers, who need to find other revenue streams, as well as for network operators, who, with fewer reasons to pull users back into their stores, see a steady rise in SIM only contracts. In the UK, bundled contracts with phones now account for fewer than half of all new contracts [4].

One consequence is that consumers have a bit more money to spend on accessories. What might have felt like an indulgence when you were paying \$30 a month for your phone becomes much more affordable when you're keeping the phone for an extra six to twelve months. That subtle change means consumers are more prepared to think about the stuff their phone connects to, and how they can enhance their phone experience. It's good news for hearables manufacturers, but not so much for cellular providers, who begin to look more like connectivity utilities.

Whilst some argue that the arrival of 5G will reverse that trend, it has yet to prove itself compelling to users. Smartphone sales are falling because tech is outrunning user applications. More speed is not likely to change that. The industry wisdom is that operators lose money on the odd numbered "G"s, as they offer few new features to engage consumers. 5G looks set to prove that [5].

Despite the slowdown in sales, the number of smartphones in use continues to increase, as users keep their phones longer and then pass them on. In 2019, there were around 3.2 billion active

smartphones [6], but that is likely to increase to around 4.5 billion by the end of 2025 [7].



Sources: GSMA, Statista

Figure 2. Active smartphone subscriptions continue to grow

In 2025, the global population is predicted to reach 8.1 billion [8]. If we take out the under 10s, that gives us 6.8 billion, implying that around 66% of them will have smartphones, with the likelihood that they will all have internet access on their phones. The question is what they will do with them?

The rise of streaming

Once upon a time we used our phones primarily for making phone calls. The quality of the internal microphone and speaker was sufficient for that, or if you needed, you could get a Bluetooth headset to allow you to stay legal while you were driving. The advent of smartphones gave us something else to do instead of making calls, turning our phones into little portable computers and ushering in a new era of ways to divert ourselves when we were on the move or on our own. The appearance of cameras played to the selfie revolution, which in turn made applications like Facebook and Instagram de rigueur, as users decided to make their lives public.

In the last five years we've found a new passion, which is to plug ourselves in to music streaming services. It's interesting that the ability to play music on the move pre-dated this. We had the Sony Walkman in 1979 [9], and the first portable MP3 player in 1998 [10]. From October 2001 the iPod set the standard for mobile music, with companies like Samsung adding Bluetooth to MP3 players from 2006 [11]. But music took time to establish itself on mobile phones. Although most phones had MP3 players from the early 2000s (the highly popular Nokia 3310 being one of the first), loading music onto them was a chore, generally needing a connection to a PC. It could also be expensive as you paid for individual tracks. Those weren't massive barriers, but they were big enough to limit usage. Instead, simple games and social media apps on smartphones monopolised user attention.

That changed when Spotify arrived. Although launched in 2008, it took it until 2012 to get over 20 million subscribers, of which around a quarter paid a subscription for the service. It wasn't just that it

was affordable (free if you didn't mind the adverts), but it made listening to music easy. You didn't even need to put together your own playlist – you could let Spotify's algorithms and community do it for you.

In the previous edition of this report I looked at the point where wireless headphone sales started to overtake wired headphones, as shown below:

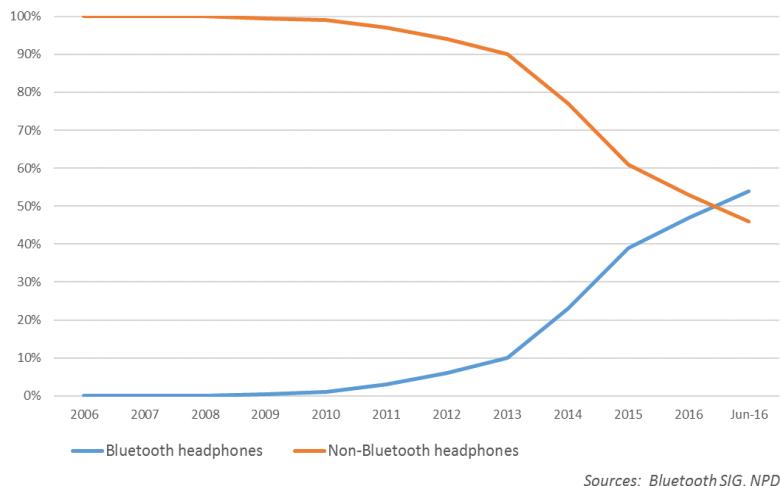


Figure 3. The growth of wireless headphone sales

It's interesting to compare it with the growth of Spotify subscriber numbers over the same period. Goodwater Capital [12] have a useful chart showing the growth over the same period. There is a surprising correlation between the two. Users were starting to stream music at the same time as showing a preference to cut the cord.

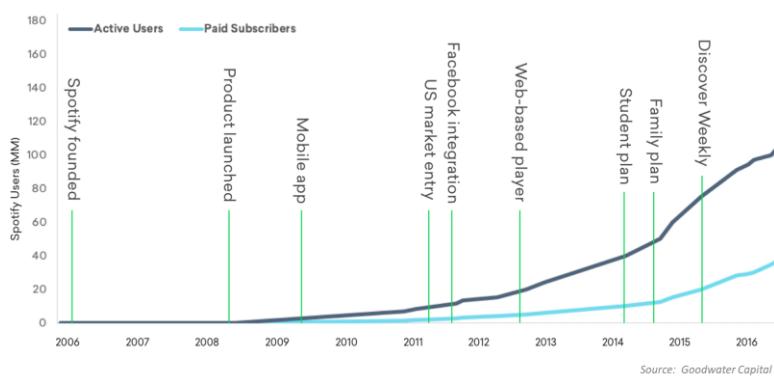


Figure 4. The growth of Spotify users

Spotify started the trend, but they're not alone. Big names, such as Apple and Amazon have joined the fray, alongside other startups like iHeart Radio and Pandora [13]. If you look at analyst reports, the view is that there are currently around 1 billion users streaming music on a regular monthly basis,

which will grow to 1.27 billion by 2025 [14]. I think that's a major underestimate, largely because it takes a Western-centric approach which concentrates on revenue. Goldman Sachs acknowledges that, but then misses the point when it states that "Developed markets are anticipated to see streaming on smartphones grow from 18% in 2018 to 37% in 2030, while emerging markets could more than triple from 3% to 10% in the same time frame [15]." It may be valid for people interested in monetising streaming, but ignores the fact that in much of the rest of the world, music streaming has different dynamics.

A good example is India, where JioSavnn offer their music streaming platform for free. JioSavnn has about 150 million active monthly users, but only 1% of them pay for the service. They claim that their users stream music for around 21.5 hours each week; four hours more than the average in the rest of the world [16].

China has yet another model. It has one of the highest percentages of population that stream music – allegedly around 48% [17] streaming every week. The names we know in the West are largely missing, with home-grown companies including KuGou, QQ Music, KuWo, NetEase Cloud Music and Tencent [18] dominating the market. The revenue model often relies on after-consumption rather than upfront payments, where users can send virtual gifts via their apps. That's a model which has also grown with short-term video streaming, which has been led by Douyin in China, better known under the TikTok brand elsewhere. Despite some legal challenges in the West, it is going from strength to strength in China, with an estimated 500 million regular users. It allows in-app search and purchase, providing a non-subscription revenue model. A further 360 million Chinese users subscribe to Kuaishou – its main rival, with another 100 million using short-term video services from Tencent and Baidu [19].

Within the short-term video arena, we should not forget YouTube, which probably has the largest user base of any mobile app. YouTube claims 1.9 billion logged-in users, of which almost 1.2 billion are using mobile devices [20]. Nor should we miss out the increasing number of video streaming channels. They're aimed at more extended viewing and listening periods, but are a driver for higher quality earbuds. Gaming is also adding subscribers, particularly in China, where it is notable that watching mobile games has a large audience [21] – something that is not seen in the West, where services like Twitch concentrate on mainstream gaming. There's allegedly a \$13 billion market for social Karaoke in China [18], with WeSing [22] leading the pack, but we've probably already got enough input to estimate the market without taking to song.

Figure 5 shows the current industry predictions of how many phone users use a streaming service. Statista reckons that it's currently around 1.02 billion, rising to 1.274 in 2024. Goldman Sachs are a little more conservative, putting the current figure at 610 million, rising to 1.24 billion in 2025. To put these figures in perspective, I've shown them as a percentage of the overall number of active smartphones in use for each year. The Statista numbers show a fall in the percentage of smartphone users who are streaming, which doesn't feel right, whilst the Goldman Sachs numbers show a gradual rise from 19% today to 27% in 2025.

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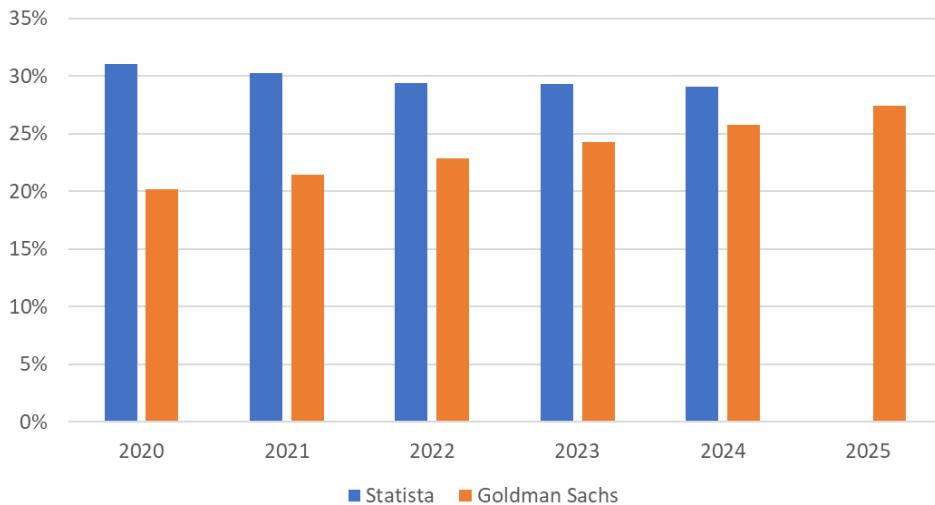


Figure 5. Predictions of the percentage of phone owners using a streaming service

The IFPI report on streaming from the recording industry [23] doesn't help much, as it's equally pessimistic, putting the percentage of people streaming on their phones at 27%, with much of that attributed to video streaming. I don't believe these reflect reality. They may relate to paid subscriptions, but if we want to understand the hearables market, we need to determine how many people will be regularly listening to some form of audio streaming service.

Table 1 shows the Monthly Active User (MAU) numbers in millions for the major streaming services around the world. It excludes those focused primarily on video streaming, as there's not a clear breakdown between mobile and TV / fixed screen usage. I should stress that these are not app download numbers, but active users, which may be free or paid subscriptions.

YouTube	1,170
NetEase	600
Douyin	500
Kuaishou	360
Spotify	217
Soundcloud	175
JioSavnn	150
iHeart Radio	128
Gaana	125
Other China	100
Pandora	63
Apple Music	56
Amazon	32
	3,676

Table 1. Active Monthly Users (millions) for major streaming services

Obviously, many users will use more than one service, but YouTube's 1.17 billion mobile users tells us

that the baseline is 1.17 billion. Assuming that YouTube is not ubiquitous and that some users look elsewhere for short videos, especially in China, I'd estimate that the starting point for streaming is around 1.5 billion users in 2019, representing 47% of all smartphones.

The point of this exercise is to come up with an estimate of the Total Addressable Market for hearables, which I would suggest is the number of people who are regularly streaming audio to their phones. To find the Total Addressable Market for Wireless headphones and earbuds, I've assumed that each year the adoption of streaming services will grow by a further 4%, (which is probably pessimistic), plus the user base will be swelled by 134 million new teenagers acquiring phones each year, of which 80% will stream audio. Again, that's probably pessimistic. Putting those numbers together give a much more aggressive set of figures than we see from other analysts, as shown in Figure 7.

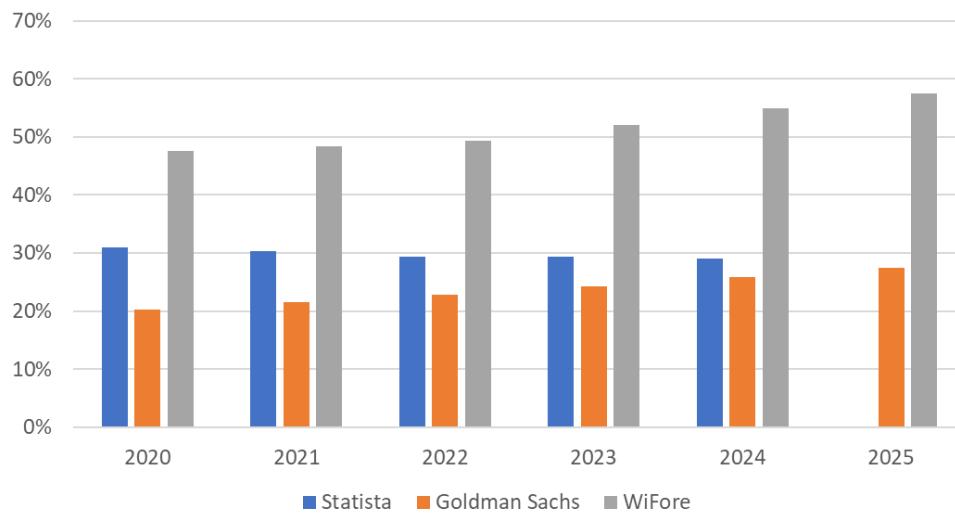


Figure 6. WiFore predictions of the percentage of phone owners using a streaming service

In 2025, it predicts that 57% of smartphone owners will be streaming audio, which is just over half of them. That doesn't seem unreasonable. Working from that, we now have an estimate of the Total Addressable Market. Figure 7 shows that in 2025, that should be just over 2.6 billion users. To put that in perspective, that's still only 57% of smartphone users.

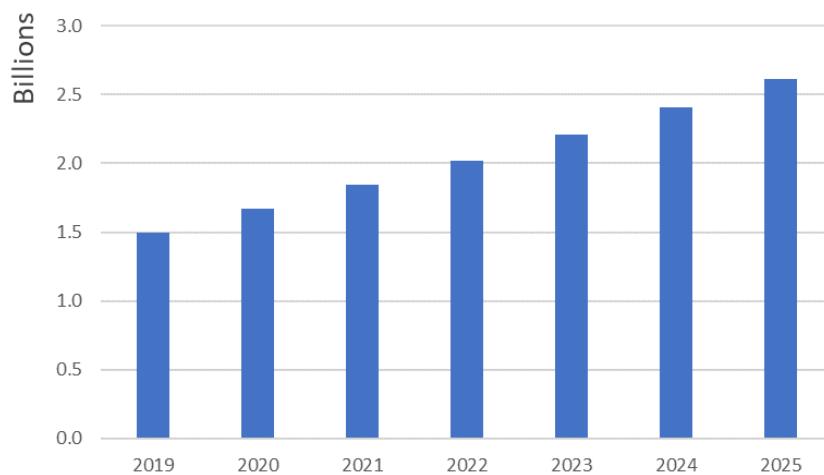


Figure 7. Total Addressable Market for Wireless Headphones and Earbuds

Knowing the TAM doesn't give us market predictions – it's basically the cap on the numbers, assuming that users only buy one set each. To get a feel for the actual market size, we need to look at the other factors which will influence sales.

Technical Considerations

The evolution of hearables, particularly in the case of earbuds, looks as if it will fall into four phases.

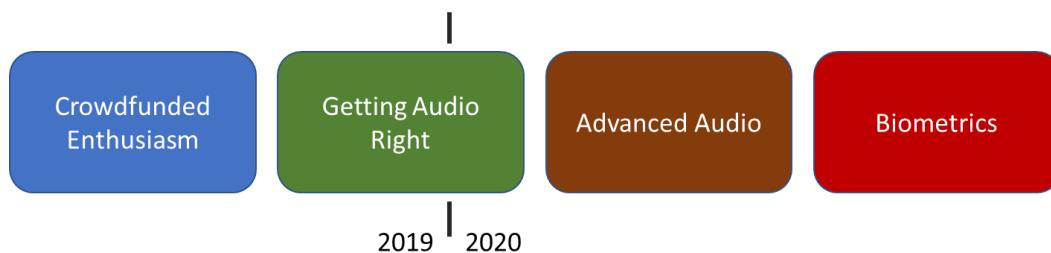


Figure 8. The evolution of hearables

At the start of 2014, Bragi kicked it all off with their crowdfunding campaign for the Dash. It was an amazing piece of engineering, which promised to cram almost every feature you could think of into a pair of earbuds. To their credit, they managed to ship the Dash, but realised that to be compelling, it's not enough to just integrate the technology – you need to find a use for it. In the following two years, other crowdfunded projects dreamt up even more complexity and managed to gather around \$50 million dollars of funding. Many failed to deliver, coming to realise just how hard it is to cram that amount of complexity into a small earbud. Hardware is hard. Most fell by the wayside, and even Bragi was forced to make the difficult decision to move out of hardware, selling its product range. Doppler, another key crowdfunded startup, did similarly. At the point where the startups were struggling, Apple launched its AirPods and the rest is history.

The arrival of the AirPods heralded the second phase of the hearables market evolution, where biometrics and additional tech was thrown out to concentrate on making the audio quality as good as possible. From 2016 until the start of 2019, Apple largely had the field to itself, helped by having designed their own chips – first the W1, and then introducing their H1 in their second generation AirPods and the Pro.

The evolution of Bluetooth audio chips

The early hearables almost all depended on a generation of silicon which had been designed by Cambridge Silicon Radio prior to its acquisition by Qualcomm – the CSR 8675. It allowed some clever tricks to be played to synchronise independent left and right earbuds, leading to a range of proprietary solutions that could deliver True Wireless connectivity. Where there were problems in getting signals across the head (as the brain is a very good absorber of the 2.4GHz radio waves which Bluetooth uses), NXP semiconductors had a complementary Near Field Magnetic Induction (NFMI) chipset which could cope with any such issues. But these were fairly old designs. Whilst Apple was able to power ahead with its own silicon, everyone else was stuck with chipsets that dated back to 2011.

That all changed in 2018 when Qualcomm announced their next generation Bluetooth audio chipset aimed specifically at wireless earbuds and hearables. The QCC5100 [24] series offered low power, a quad-core processor, dual DSP and a very comprehensive set of development tools. Qualcomm also announced an Extension Program of partners who could offer additional audio capabilities, such as audio enhancement and biometric algorithms [25].

A year later, Broadcom made a similar announcement, offering earbud manufacturers their BCM43104 range [26]. It had evolved as part of a joint development with Samsung to produce the silicon for their Galaxy Buds. It also offers advance audio processing capabilities and low power.

The most recent chipset announcement came from Huawei with the launch of their Freebuds 3. Like Apple, Huawei had designed their own specialist Bluetooth audio chip – the Kirin A1, using their semiconductor subsidiary HiSilicon. In the course of just 15 months, we have seen three new advanced Bluetooth audio chipsets challenge the H1 used by Apple and Beats. Samsung and Huawei have already launched earbuds which are credible alternatives to Apple's AirPods and which seem to be selling well. Huawei claim that over a hundred thousand Freebuds were sold of the first day they became available. 2020 will see a whole lot more appear, with offerings at a range of prices. The competition for the ear is heating up.

Getting audio right

Going back to the second phase of hearables, Apple has been concentrating on getting audio right. Their priority has been to take the performance of wireless earbuds to the same level as wired ones. The challenge has been both physical and technical. Wireless earbuds need to contain their own power source (the battery), which takes up a fair amount of available space. Even the low power of a Bluetooth connection drains the battery fairly quickly, especially with the codecs used in most phones (of which more later). Using a battery with sufficient capacity to give more than a few hours of playing time means you have to trade off space, which potentially leaves less room for decent transducers to reproduce the sound. As hearing aid companies have long understood, the battle

between battery life and weight (and hence comfort) is a tricky one. A further complication is that the physical shape of an earbud needs to fit in the ear, stay there, be comfortable and provide the correct acoustic environment to generate audio. Until recently there was considerable debate about whether it needed to seal the ear, particularly if you wanted to perform noise cancellation, known as the “loose fit” conundrum. But some neat technology from AMS in Austria has put that one to rest. For anyone interested, there’s a great explanation about loose fit in Audio Express’ newsletter #249 [27].

Earbuds have one advantage over hearing aids, which is that users typically take them out every few hours to do something else, such as having a conversation. Manufacturers have realised that gives the opportunity to fast charge them, so that when the user puts them back in their ears they have another couple of hours of play time. Apple cracked this with the AirPod case which is so easy to use that it encourages you to put your AirPods back, rather than leave them lying on the desk. That still leaves the problem of remembering to charge the docking case, but the addition of wireless charging makes that less of a hassle. Samsung have gone one stage further, allowing users to wirelessly charge their Galaxy Buds or their charging case by placing them on their phone. It would still be nice to have a battery which lasted a full day, but these workarounds make the current generation of earbuds more than usable.

Battery life is important, as if your earbuds spend more of the day being charged than playing music, they’ll soon be discarded. But the quality of music needs to be great if everyone is going to want to use them. Whilst a number of early implementations of the Bluetooth audio specs left something to be desired, those issues have long been overcome. The specifications have been tightened up to ensure compatibility between different manufacturers and companies have introduced more efficient codecs, which improve the quality of sound. Bluetooth’s mSBC gives good performance in many products, whilst Apple have standardised on the Advanced Audio Codec (AAC). Companies wanting higher quality can turn to the AptX codec offered by Qualcomm, or Sony’s LDAC. These codecs mean that the quality of the audio signal arriving at the earbud or headphone is essentially the same as the audio signal in the phone. The next challenge is in turning that into an audio output in the ear.

Again, technology has evolved to help. Hearing aid manufacturers, along with companies making high quality earbuds for musicians, have driven acoustic engineering forward over the past few years. Balanced armatures – once the province of high-end audio earbuds and hearing aids are now available for consumer products, and there has been a resurgence of acoustic engineering, resulting in clever cavity designs that achieve high quality audio output from traditional voice coils. The market is also seeing the introduction of MEMS speakers which could add a further element to audio quality. A leading example is U-Sound’s Achelous high-resolution speaker on a chip which is just 6.7mm x 4.7mm, and only 1.5mm thick [28]. Hearables are also benefiting from developments in home assistants where microphones are being integrated with Digital Signal Processing chips, either to detect wake words or help to implement directional microphone arrays. Knowles – the leading supplier of miniature microphones, with around 38% market share, has started shipping complex, miniature audio system components, adding DSP functionality to its MEMS microphones. They have recently bolstered their capability with the acquisition of AMS’ microphone ASIC team to give them direct control of the silicon supply [29], as well as access to AMS’ loose fit ALC technology [30].

We've already mentioned the issue of synchronising left and right earbuds, and the proprietary approaches that are currently needed. Manufacturers of wireless earbuds also have to contend with the problem of ensuring that the Bluetooth wireless link remains robust between a phone and both earbuds. That problem is at its worst in the "back pocket scenario", where the phone is in your rear trouser pocket, allowing a large percentage of the radio transmission to be absorbed by your torso. Turning your head can cause the link to drop to one earbud, resulting in gaps in the music.

When you're inside, it's generally not a problem. At 2.4GHz, radio waves don't just travel in a straight line between transmitter and receiver, they're reflected off walls and ceiling, so it's likely that they will get through. Go outside and the reflections disappear, resulting in a much greater likelihood of failure and audio dropouts. This is one of the biggest problems for product designers. The smaller the earbud, the more likely it is that the antenna will be partially inside the ear, decreasing its efficiency. You can increase the sensitivity of the radio in the earbud, but that's likely to use more power, reducing the battery life. For earbud designers, everything is a balancing act, which is what makes it so hard to get them right. Today's generation of chips give just about enough room for manoeuvre for designers, but it is a major challenge to optimise battery life, audio quality and robustness. That challenge is about to get a little easier, with the introduction of Bluetooth Low Energy Audio, starting with the release of the 5.2 version of the Bluetooth specification.

The impact of Bluetooth Low Energy audio

Specifications always take longer to arrive than everyone expects – particularly wireless specifications. That's been true for the Bluetooth SIG's new 5.2 release, which provides the core features for transferring audio using Bluetooth Low Energy. It's now complete and released, allowing companies to start planning new features. During the course of the year, we'll see a raft of new Bluetooth audio profiles appearing, fleshing out the initial core standard.

Originally conceived by hearing aid companies, it has grown into one of the largest development efforts in the Bluetooth SIG's history, laying down specifications to support the next twenty years of wireless audio innovation. It takes advantage of the lower power possible using the Bluetooth Low Energy standard, but accompanies that with better audio quality through the introduction of a new codec called LC3, and supports a much wider range of audio topologies.

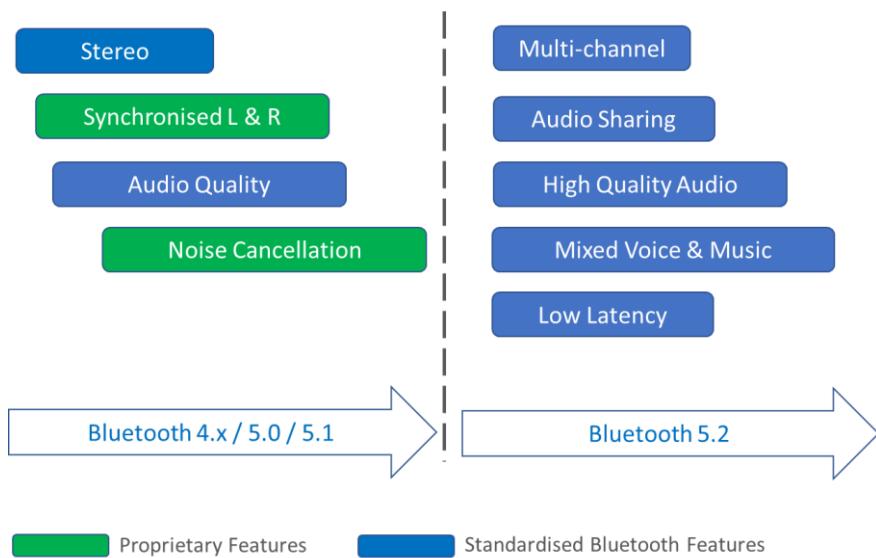


Figure 9. The evolution of the Bluetooth audio standards

Figure 9 illustrates the evolution of the components which are required to make hearables. Today, all of the products on the market utilise versions of the Bluetooth standards which have been around for some time. (It's fifteen years since the first A2DP compliant products for music were released). The earbuds we have today rely on manufacturers extending these specifications to get around their limitations, such as the lack of support for true stereo streaming. With the 5.2 release, those limitations disappear, making it far easier for companies to design high performance, interoperable audio products. Looking beyond that, the release opens up exciting new applications, in particular:

- Allowing audio to be streamed to multiple different devices. That provides exact synchronisation of music being rendered, not just on left and right earbuds, but across multiple speakers.
- An ability to share audio, either in a location such as a theatre or café, where it will begin to replace the old hearing aid telecoil system, but also between friends on an ad-hoc basis.
- Mixing voice and music at the same time, so that you can issue commands to your music player or smart home devices without interrupting the music you're listening to, and
- Adding a high performance codec which will deliver quality audio at lower power and with the ability to reduce latency.

Put together, these features give designers more flexibility to balance the performance parameters of hearables, as well as designing new products and experiences to extend our use of audio.

As always, it will take time for these features to appear in the market, and in the medium term most hearable products will probably combine both Bluetooth's existing audio features and the new ones supported by the 5.2 release. But as the new experiences, such as audio sharing, appear in phones and hearables, we are likely to see a growth in purchases as consumers embrace these new audio experiences.

Audio Augmentation

Having got the basics of delivering high quality audio complete, Apple and competitors have been looking at how to enhance that, which takes us into the third phase of the hearables evolution; enhancing the audio.

The first step is to add Adaptive Noise Cancellation (ANC), which reduces the amount of external noise by employing microphones within and outside the ear, so that external sounds can be subtracted from the music being played. For years, this was Bose's speciality, but as patents have expired and audio algorithms have developed, it is technology that can be readily purchased and integrated into any form of headset. Apple have introduced it into their PRO AirPods, taking advantage of its presence to add \$90 to the price tag. Huawei also offer it in their Freebuds. Bose have it in their wireless earbuds and have also licensed it to Amazon for the Echo Buds. By the end of 2020, it should be standard in any earbud over \$100, and probably quite a few cheaper ones.

Reducing outside noise is a useful feature, but there has long been a concern that shutting yourself off from any outside sound can be dangerous. Back in 2011, legislators in Arkansas and New York considered placing restrictions on using cell phones and music players, such as iPods, by people running and walking on a street or sidewalk, as they believed that "distracted pedestrians are dangerous" [31]. Research published later that year showed they may have had a point. It revealed that there had been 116 deaths in the US as a result of pedestrians wearing headphones between 2004 and 2011 [32].

That concern has led to the development of "situational awareness", where external microphones capture and mix a proportion of the sounds around you, typically marketing it as ambient blending or pass-through audio. More complex algorithms for sound detection are now arriving which will automatically attempt to detect relevant sounds, such as traffic approaching or a voice appearing to address you and adjust the level of blend to make you aware of it.

As the Qualcomm partner list shows, there are plenty of specialist audio companies lining up to offer solutions to manufacturers to bring their products to market more quickly, or to help them differentiate themselves in what is becoming a crowded space. To pick just a few areas where specialist partners are helping to drive innovation, Sensory Inc. help companies identify sounds as well as wakewords [33], as does Rubidium Ltd who embed wakewords – turning voice into actions [34].

With a somewhat wider remit of working with sound as well as voice, we have Alango [35], who have been putting audio algorithms into cars for years, along with Audio Analytic [36], who are serious about the way we treat sound in general. Earlier in the year Audio Analytic commissioned a useful hearables report, looking at attitudes and expectation to AI in audio [37].

We're seeing an interesting convergence between audiology and listening experience. I'll expand on this more in the section on hearing aids, but companies that had focused on hearing loss are beginning to turn their attention to enhancing how we hear music by profiling a listener's hearing and adapting the sound to meet their expectations. Amongst them, Absolute Audio Lab are offering operating systems for smart audio as well as adapting sound to your hearing ability [38]. Mimi, who

have been working in this area for ages, offer personalised audio experiences [39], whilst Aumeo go one step further, bringing clinical grade audiology [40]. None put it quite so clearly as Danny Aronson of Even, who has long argued that it's all about "Getting your music back. When you hit 50, you don't hear like an 18 year old" [41]. That may be the most persuasive message to wake users up to the reality of hearing loss.

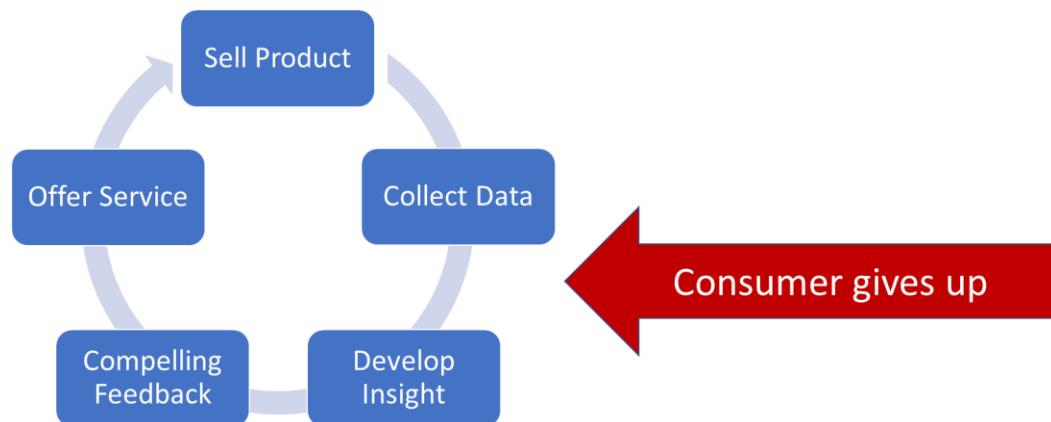
Finally, to show the range of companies entering the arena, Sonion, one of the leading suppliers of microphones and balanced armature drivers, now offer voice pick up bone sensors which integrate with Qualcomm's chips [42].

Phase 4. The ear is the new wrist.

I wrote that phrase "The ear is the new wrist" back in 2014, when it looked as if hearables would take over from wristbands as the ideal location for biometric sensors [43]. Since then I've seen the phrase reused by hearing aid vendors, hearable manufacturers and analysts, but I've not seen the promise fulfilled. There's not much argument that the ear is the best place for measuring most things. It's designed to be static – it doesn't get waved around like your wrist; it's insulated from the everyday wear and tear of the rest of the body and lots of the things you want to measure are close to the surface. There were scholarly articles about the benefits from the early 2000s [44]. Jabra's CEO, René Tune-Svendsen took the same line in June 2015 [45] and earlier this year, Dolby's Chief Scientist, Poppy Crum, reiterated the advantages in an article in IEEE spectrum [46]. Where did we all go wrong?

To find the answer we probably need to look at wristbands. When wearables were taking off, back in 2012-13, companies like Fitbit were seen by many as the answer to an impending health crisis. By telling people about their level of activity, it was thought that they would modify their behaviour. Plenty of companies jumped on the bandwagon, most of whom no longer exist. Even Fitbit has gone. At its peak, it was valued at just under \$10 billion. At the start of 2019 it was down to \$770 million, at which point Google saved it by acquiring it for \$2.1 billion. It wasn't that Fitbit hadn't tried – they'd developed smart watches, partnered with insurers, tried to set up company wellness schemes and offered consumers every flavour of application, but at the end of the day, most Fitbits ended up in the back of a drawer. Consumers just weren't that interested.

It demonstrates a rather unpleasant Catch 22 which has bedevilled the personal health product industry, which is that it is incredibly difficult to engage users.

**Figure 10. The Catch 22 of consumer healthcare**

The problem with any health or fitness application is that the raw data isn't very interesting. It's fun to see how many steps you do, run a couple of blood pressure measurements, or see some ECG scans, but they don't tell you much about your real state of health unless you've got a major problem. In health and fitness, you need to look at trends and compare those with a wide cross section of the population to find out where you sit. At that point, the hope is that you can provide tailored feedback to a user to help them change their behaviour to generate a "healthier" lifestyle. To do that you need to capture a lot of data from a lot of people, which is likely to take several years.

Without that compelling feedback, most users quickly lose interest and the fitness device goes into the drawer. You not only lose the user, you lose any further data from them, which makes it more difficult to generate any compelling applications for your remaining customers. This is a particular problem for devices like wristbands, where data feedback is their *raison d'être*. It is why I have always considered that hearables would prove to be the most successful segment of the wearables market, for the simple reason that they don't need to collect data – they consume pre-existing data in the form of streamed music. Apple get that, which is why they've not added any biometrics to their AirPods. Yet.

History has shown us how difficult it is to change consumer behaviour, particularly in terms of health. It took fifty years to change smoking habits and we've barely started on obesity. It's why public health messages are so generic, like the UK's "5-a-Day" message to persuade people to eat five pieces of fruit or vegetables each day, and the almost universal exhortation from every step-counting device to do 10,000 steps a day. Incidentally, they both have little if any scientific basis, relying on the "more than before" approach of aiming for something beyond the current average. The 10,000 step goal dates back to 1965, when the Japanese company Yamasa marketed their pedometer as Manpo-kei, which translates as "10,000 step device" [47], which I suspect was chosen as it sounded right, even though it was blindingly obvious. A bit like Volkswagen, which hasn't done too badly as an obvious brand name. The Manpo-kei was popular enough to generate walking clubs amongst health-conscious Japanese, something our more recent connected devices have failed to achieve.

years on, only a small number of wearers use these features, with most only using it to count steps. Apple's approach may be a stealth one, letting them accumulate data from willing users in order to develop future services. In which case we may see biometrics appearing in some future version of AirPod.



Figure 11. The evolution of biometrics in Apple's Watch

Before returning to hearables, it's worth pointing out that there is a significant cost to providing this feedback. Companies need to acquire a lot of data and put a lot of effort into analysing it to provide compelling feedback, all of which costs money and time. While many yearn for the ability to have a sufficiently compelling service that they can charge a monthly subscription fee, few have managed that, particularly at scale. To understand the scale of those ongoing costs, I'd recommend a white paper from Pilgrim Beart – one of the pioneers of the IoT, on why many connected products lose money [48]. Few companies have the resources to support that level of data gathering and analytics.

For these reasons, I suspect that we won't see much consumer enthusiasm for biometrics in hearables in the next five years. Google and Apple are probably the only potential players who could do something in that timescale and neither need to rush to lead the market. Despite my original enthusiasm, I don't see biometrics in the ear being a reason to buy a hearable until the end of the decade.

The Psychology of Earbuds

Why are we so addicted to streaming music? The market size predictions I'm presenting are largely based on our passion for listening to music and the fact that wireless earbuds makes it easier to do. For most people, easier is better and that is what I see driving this market. However, it is helpful to ask what has changed, if only to consider what other changes may be in store.

If you go back a hundred years, music was not part of most people's day, unless you were singing it yourself. Fifty years later it had become more prevalent with the advent of radio, but it was still reserved for specific occasions, rather than a constant background. During the second world war, the BBC experimented with their "Music While You Work" program, broadcasting half an hour's music twice a day to help boost factory workers morale [49]. But music was mostly an occasional treat.

The arrival of the transistor radio in the 60s brought more regular listening to teenagers, but it was generally confined to the home. It wasn't until the arrival of the iPod in 2001 that people began to listen to music on the move. Attitudes in the workplace began to change around that time, with people starting to listen to their own music for more of the day, particularly with the growth of shared and open-plan offices. Colleagues began to stop talking to each other; rather than unplug their music they would use email and the new messaging systems to communicate. Offices became as silent as those in Dickensian novels, with just the hum of fans and the tapping of keys. As streaming arrived, the addiction grew, with people hearing only their playlists from the start of their commute to returning home.

There are hearing health issues here, which we'll look at later on, but also social ones. Anthropologists like Sherry Turkle have explored the effect of digital technology in her books "Alone Together" and "Reclaiming Conversation", observing that "people use technology to escape from reality and emotions, which weakens genuine relationships". Her books deal largely with our addiction to screens. However fixated we are on a screen, we can still hear someone ask us a question. There is a need for similar analysis of our addiction to music and the way we use it to isolate ourselves from the world around us, whether that's in the workspace or a public area.

The industry seems to believe that we need more, rather than less. Earlier this year, Harman – a leading company in audio design, commissioned a report on the Future of Listening [50]. In presenting it, Carsten Olesen, their President of consumer audio, posited that "the visual world is losing its appeal" and that consumers are shifting to sound instead. The report identified that more than 50% of consumers consider audio a great escape from "visual overstimulation," while 91% said that music in their daily life eases modern-day pressures. So much so, that the majority intends to increase music consumption. The headline numbers are

- 91% Believe music eases everyday pressures
- 90% Consider sound an integral part of life
- 57% Report their music consumption has increased compared to a year ago

It's a similar message to Qualcomm's State of Play 2019 report [51], which concludes that "with the wireless freedom to listen to tunes on-the-go, people want to add a soundtrack to their whole day". The content providers think along the same lines (it's been a good year for upbeat reports), where Spotify profiled Generation Z in their "Culture New Trends" report [52], discovering that whilst Gen Z may appear to be obsessed with their screens, they value audio as an escape from visual stimulation overload, saying it isn't just background noise". However, only 50% report that it plays a huge role in their everyday lives, rather less than the Harman sample.

None of these tell us much about behaviour and why so many want to distance themselves from the world around them. Despite that, we are already see some intriguing new behaviours from earbuds. The most significant is that with most of them, when you take an earbud out, the music stops playing. Users have highlighted that as a major benefit. I suspect that reflects an underlying concern that if you're wearing over the ear headphones, people consider that to be a statement that you don't want to be disturbed. Earbuds are far less of a visual barrier, and the ease of taking them out and holding a conversation lowers any feeling of resentment. If that is the case, it may mark the beginning of the

end for consumer headphones, relegating them back to their original audiophile market.

The isolation of audio may diminish when the audio sharing features of the new Bluetooth specification arrive in products. As well as letting all hearables wearers listen to local sound, such as in concerts, theatres, shops and public announcements, it also lets you share your audio with friends, so that you can listen to each other's tracks. It's early to speculate exactly how that will be used – the specification just defines the enabling technology, but already people are talking about its use for shared music, karaoke, group storytelling and impromptu silent discos. If it encourages more social interaction it will be a good thing. In the meantime, we need a better understanding of how long-term music streaming is affecting our behaviour.

The Market Opportunity

In my previous report in 2016 I generated the figure below to identify the different target market for hearables. At the time it looked as if there might be significant growth in most of the different sectors. The reality has been rather different. Whilst companies have brought almost all of these product segments to the market, the overwhelming success has been in earbuds for audio playback. Rather than emerging as sectors in their own right over the next five years, I suspect that most will gradually be absorbed into earbuds as differentiating features. The exception is hearing aids and augmented hearing. Before looking at the detailed numbers, it's useful to look at that sector, as the combination of regulation and a growing awareness of hearing may well influence the direction of other hearables. There are other subsegments, such as gaming and high quality audio, but I see those as niches within the mainstream hearables sectors.

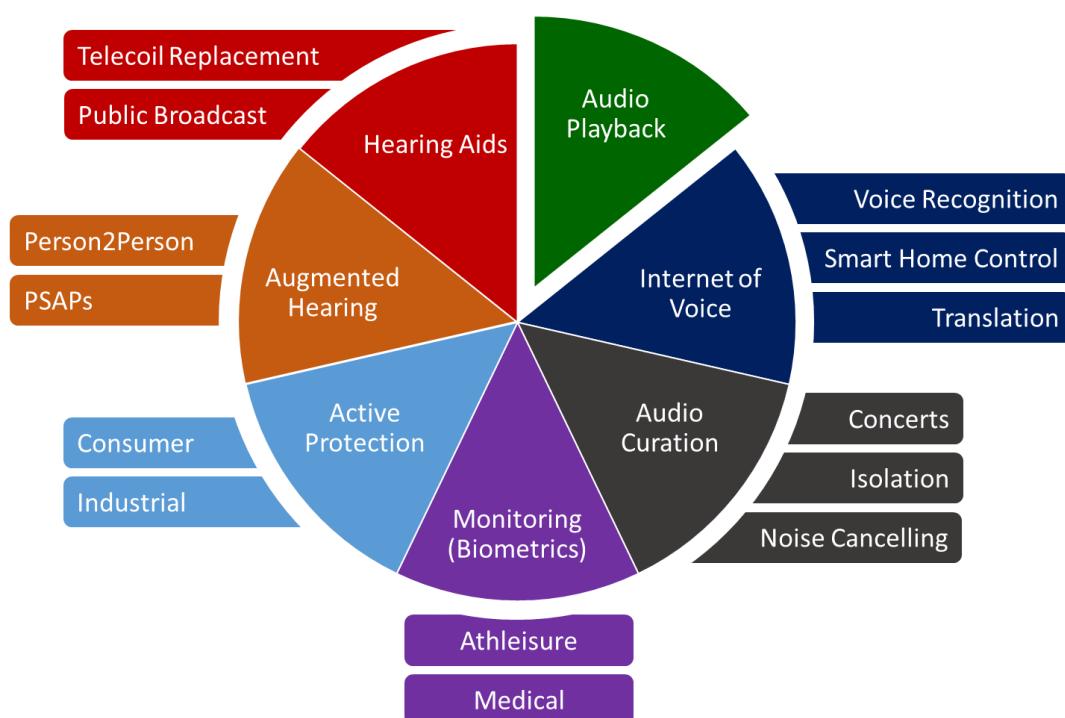


Figure 12. Market segmentation for hearables

Hearing Loss, Hearing Gains, Hearing Aids and Regulation

Hearing loss is something that most of us will need to deal with at some point in our lives. Most of us suffer from some degree of it as we age, and since the start of the industrial revolution we have seen that worsen with workplace noise leaving many people with severe hearing loss by the time they retire. Most Western, industrialised nations have addressed that through health and safety legislation, so that exposure to loud noises have been significantly reduced, but being the perverse creatures that we are, we're voluntarily damaging our hearing at an even younger age by listening to loud music. The effect of that is that many thirty-year olds have similar hearing loss to that which their grandparents had at sixty. The World Health Organisation (WHO) has estimated that around 1.1 billion young people under the age of 30 are at serious risk of hearing loss because of their levels of sound exposure [53]. More recently, they have estimated that 466 million people worldwide have disabling levels of hearing loss, which will rise to 900 million by 2050 [54].

Hearing loss is a problem which is generally ignored. The hearing aid industry has observed that most people with hearing loss put off getting their first hearing aid for almost ten years after they need it. It's often felt that the event which generates that is marital conflict over ownership of the TV volume control, where the options are getting a hearing aid or a divorce. That domestic conflict scenario was used rather well in an Australian TV campaign promoting hearing tests [55]; unfortunately it was banned after complaints that it depicted domestic violence. Other well-intentioned attempts to remove the stigma associated with hearing aids, such as Widex's in-your-face campaign in New Zealand [56], have also faced similar bans as a result of public complaints. It is ironic that industry regulators have inadvertently managed to keep hearing aid promotion limited to the elderly.

There is a serious side to this. Hearing loss isolates people, both at home and at work. That isolation has impacts on the family, makes social interaction more difficult, increasing conjugal friction, leading to a loss of spontaneity and a gradual withdrawal from society [57]. The effects of that appear as medical issues, with increased levels of stress and depression. The WHO report estimates that the annual global cost to society of untreated hearing loss is \$750 billion. That's about the GDP of Switzerland. Yet we still struggle to combat the stigma and persuade people to wear hearing aids.

Hearing gains

On the positive side, awareness seems to be growing, particularly within the younger generation. I like the approach of promoting the concept of Hearing Gains, which is a mainstay of Mumbli [58], a hearing wellness platform. They believe hearing is a social sense that is barely understood, let alone open, explored and addressed. When it is addressed it is often through the stigma of hearing loss. Rather than attacking the stigma of hearing loss with all its incumbent politics, biases, branding legacy and regulations, Mumbli is focusing on the growing and rapidly disrupting trends of hearables and wellness to reframe the health narrative, including an understanding of how to manage and make intelligent choices about the sound levels in spaces around us.

The Good Hearing Initiative [59] is another attempt to raise awareness. Based in Berlin, it was founded by two people who had previously worked at Mimi [39], and has a target to make people more aware of hearing loss and to gather information by promoting online hearing tests, with a goal of running one million tests a year. They're not the only ones bringing hearing tests online. Nuheara – one of the

original crowdfunded hearable companies, who are still going strong, are offering a free online test [60]. They're also being made available by the majority of hearing aid companies and audiology chains. The industry needs to work to promote them to a younger audience. If you've not had your hearing tested, try one or two of them and encourage your friends and family to do the same.

The hearing aid industry

The growth of hearables, and particularly of earbuds, owes a lot to the hearing aid industry. Over the years they have pushed technology to optimise audio quality and battery life, which has helped stimulate the development of smaller transducers and more efficient chips. They've also been instrumental in driving the new Bluetooth Low Energy audio standards. There's a belief that in doing so, they may be the instrument of their own demise as consumer companies encroach on their market. That was highlighted by analysts when Bose received FDA qualification for a hearing aid [61], but I think that fear is overstated.

The hearing aid industry has a very different model to the consumer audio industry. Its products are certified as medical devices and in most cases are prescribed by audiologists. Because they are expensive (because, as many startups have discovered, they are fiendishly difficult to make), they are often supplied through medical insurers or health providers. In the US, around a quarter of all hearing aids are supplied thought the VHA; in the UK, around three quarters are purchased by the National Health Service. That business model does not change quickly, not least where the purchaser's experience directs them to buy medically approved products from medically approved suppliers.

It is a business model which has kept the price of hearing aids high and various consumer groups have lobbied to make hearing aids more readily available, hoping that an increased market size would result in lower prices. In the US, new Over The Counter (OTC) legislation is about to come into force which will allow wider availability of hearing aids without the need for an audiologist's prescription. The intention is that these devices will either come with preset configurations to cope with common levels of hearing loss, or with software to configure them for the wearer. That will place them somewhere between today's hearing aids which are designed to be fitted by audiologists and the current PSAPs (Personal Sound Amplification Products), which are not medically approved or configurable.

The industry is divided over these changes. It should help to reduce the price barrier, but there's not much knowledge about how that correlates with people's reluctance to get their hearing tested. Unless that stigma is broken, the arrival of OTC hearing aids may just adjust the supply chain. If the industry can use it to encourage more people to get their hearing tested sooner, it could significantly increase the sales of hearing aids.

I believe that the more important opportunity lies at the lower end of hearing loss, where people start to realise that their hearing is not as good as it used to be. It harks back to Danny Aronson's approach of designing a consumer headset which gets your hearing back. The technology going into hearables which profile your ears is not dissimilar to that which audiologists use. I expect to see more and more hearables taking this approach, not specifically to address hearing loss, but to enhance people's enjoyment of music as they start to experience hearing loss. If manufacturers are

honest about these enhancements, it may be the most important aspect of removing the stigma of hearing aids forever.

Some of the new features of Bluetooth Low Energy Audio should also help. Today, audio infrastructure, in the form of telecoil loops, are limited to hearing aid users. As Bluetooth starts to replace these, information such as travel announcements and being able to talk to a taxi driver will become accessible to anyone with a compatible hearable. If everyday consumers adopt these, and they probably will, because they are convenient, the boundaries between hearing loss and normal hearing will start to disappear.

Hearing Aid users often complain that the real world of audio is more complex than any hearing aid can cope with. They supplement their hearing aids with additional microphones and TV streamers to help them cope with different environments. The interoperability that Bluetooth brings will make these products more accessible and equally attractive for normal users. It's interesting that Apple have opened up their Live Listen feature [62], which lets users of MFI hearing aids use their phone as an external microphone, to anyone with AirPods or Powerbeats Pro. It's a reminder that a lot of innovations from the hearing aid industry have a wider application.

In this evolving world, the major challenge for hearing aid manufacturers may be battery life. Over the years they've put enormous amounts of effort into designing hearing aids which will run for a week on miniature batteries. As wearers realise that they can stream good quality music and TV audio directly to their hearing aids, the power demands will increase, particularly if they stream for four or more hours a day. That will almost certainly mean a move to rechargeable batteries and wireless charging, which may result in rethinking the industry norm of designing smaller and lighter hearing aids to make them invisible. In many ways, that focus on invisibility has driven hearing aid design into a corner, where size and lightness leads everything else, sometimes to the detriment of usability. Once that constraint is lifted, we could see future generations of hearing aids beginning to look more like consumer earbuds. That means that the industry needs to evaluate what its real strengths are in order to combat competition from consumer audio companies attempting to enter the market.

Regulation

Regulation has done much to prevent hearing damage in the workplace. The concern now is self-inflicted damage. The World Health Organization and ITU have recently published their H.870 standard [63] with three main recommendations for safe listening:

- Every device shall measure the listener's use of sound allowance, based on a choice of two modes of reference exposure.
- Each device should include options for volume limiting and parental volume control
- Each device shall provide the user with
 - personal usage information
 - personalized messages and cues for action
 - general information on safe listening

Apple have already pledged to adopt the guidelines and other manufacturers are likely to follow. The recommendations require more monitoring and communication between hearables and smartphone,

which is essential where users mix and match hearables and phones. It means more intelligent devices, which, as the standard starts to take hold, should further increase the sales of hearables that support it. The standard also recommends tutoring, with examples of how that might appear on smart phones and watches.

Whether users will pay any more attention to these than they do the current 85 dBA warning limits on their phones and tablets remains to be seen. Most hearing researchers around the world believe that 85 dBA is the maximum level of sound for safe long term listening. In Europe every mobile audio device needs to show a warning the first time that level is exceeded, although users can ignore it and select that it never be displayed again. A recent report in BMC Public Health [64] suggests that listening levels above 90dBA are not uncommon, with some phones exceeding 100dBA. However, as more research appears about the risks, companies are likely to become more responsive, particularly as some decide to take the opportunity to become part of the hearing aid industry. It is difficult to justify that step if you are seen as one of the companies causing hearing loss in the first place.

Squeeze me, stroke me, tap me

As a final diversion before looking at the numbers, it's interesting to see how manufacturers are addressing the topic of remote control. In the days of headphones or wired earbuds, there was plenty of room for buttons to control volume, accept and reject phone calls and change track. With earbuds and hearing aids, where small size has become a primary design objective, companies have had to rethink how they implement a user interface.

Voice seems an obvious option, but it has some complications. It's possible to add support for wakewords, so that you just say Alexa or Siri, but to save power, most hearables need a tap or squeeze to let them know you're about to do that. A further annoyance is that your music generally has to pause whilst the voice command is sent to the phone. That's a limitation in the current Bluetooth specification which will disappear with the new version, but we're unlikely to see that in phones for the next year.

If you make the surface of your earbud a little larger, we get into the realm of gesture control, where a swipe of your finger can take the place of buttons. That's still a little fiddly on most earbuds, with users reporting that it takes quite a lot of practice to distinguish between the different controls. One solution, which a few manufacturers are exploring, is to make your earbud a lot bigger. Instead of being a minor addition to your ear it becomes a statement.



Figure 13. It's not just the market which is growing – hearables are growing too

The most interesting ones in this space are Microsoft and Human, shown in Figure 13. Microsoft's Surface buds [65], shown on the left in Figure 13, could not be called discrete – they're making a statement. They use the additional space for advanced gesture control that lets you control your Office applications from your ear, whether that's changing slides in a presentation or listening to your email. They also take advantage of the larger size to offer "immersive sound". Whether that's what users want is yet to be seen, but it's an interesting experiment.

Human have gone one step further with their over-ear headphones [66]. Two separate headphones clip over your ears to provide an experience somewhere between an earbud and a pair of headphones. That gives lots of room for what I find to be one of the most intuitive swiping interfaces. It also gives them the space to fit a big battery, so they don't need recharging during the day. However, what really differentiates them and makes them stand out is the fact that when clipped together, they can operate as a Bluetooth speaker and conference phone. That's a really clever trick, which indicates that there is still a lot of innovation to come in this space as companies start to think outside the box.

The Hearables Market 2020 - 2025

Which brings us to the numbers. Going back to the analysis of how many people will be using streaming services, we have the Total Addressable Market in millions of users:

2020	2021	2022	2023	2024	2025
1,667	1,841	2,022	2,210	2,406	2,609

Table 2. Total Addressable Market (Millions of users)

Not all of these users will be using hearables. Even in 2025, many will probably still be using the low-cost wired headsets which come with their phone. However, a growing number will have moved to wireless.

By 2025, Android will have gained even more market share, being used on 73% of active smartphones, with iOS on the remaining 27%. Based on current trends, Huawei and Samsung will dominate the market, taking 52% - just over half of all smartphone sales. Huawei has already overtaken Samsung to be market leader in terms of the number of handsets shipped and I expect them to increase that lead, although political interference and trade wars may well affect that. Other vendors will share the remaining 21% of the market.

The wearable attach rates for these three different sectors will differ. Apple will have the highest, rising to 45% in 2020. Having made the decision to remove the 3.5mm jack from the iPhone 7 and subsequent models, iPhone users have more reason than others to go wireless. By 2021 it looks likely that Apple will no longer sell any phone with a 3.5mm jack. Huawei and Samsung have followed Apple's lead, but they make a far wider range of handsets, many of which still do have the traditional jack. For that reason I expect them to have a lower wireless attach rate of around 33%, the majority of which

will be their own earbuds, which are currently being designed to integrate closely with their phone apps. But for that you will pay more. Both are competing with Apple and have hearables in the \$100 range.

The remainder of the Android market will be mixed in its 3.5mm jack support, but will all support Bluetooth. As many of these phones are aimed at the lower end of the market, their users are more likely to buy cheaper wireless earbuds. If you go to China, you'll find these pouring out of factories for as little as \$5. Those which follow reference designs from Qualcomm and Broadcom can be surprisingly good quality, and that will only improve over the next few years. Although owners of high-end Android phones from Samsung and Huawei may eschew these, they will probably be popular with cheaper phones, leading to a slightly higher attach rate of 39%.

I suspect that the removal of the 3.5mm jack will accelerate. From a phone manufacturer's point of view, the primary reason for removing it is space. It's physically one of the largest components on the PCB, measuring around 9mm x 7mm [67], which is about the same area as Apple's main A10 chip. Except that whereas the A10 chip is only 1mm high, the jack socket is 5.2mm high. Ironically, as phones have got bigger that's not been such a problem, but that may change. If folding phones take off, thickness is at a premium. Conversely, if the exhortations of Harman and Spotify are true, and users are beginning to feel visually over-stimulated, it may herald a return to smaller phones which fit into pockets, where the physical size of a 3.5mm jack socket becomes a major embarrassment. Either change would hasten the demise of the 3.5mm socket, with a knock-on increase in wireless attachment rates.

The irresistible rise of the smartphone manufacturer

An interesting side effect of the removal of the jack is that phone vendors are taking over the hearables market. Apple is almost certainly outselling Beats. Huawei and Samsung have their own hearables which they can (and do) bundle with phones, or use as purchase incentives with cellular operators. Each one of these sales for a connection to a premium smartphone is a sale lost to traditional hearables vendors, who need to work out how to react to this assault on their market.

Back in the beginning of 2014, when Bragi kickstarted the hearables sector, the only phone vendor with any real stake in the market was Sony, although you can argue they were always an audio brand who added phones to their range. In May that year, Apple became a major player when they acquired Beats. Two years later they launched the AirPod which has made them the market leader in their own right. In 2017, Samsung acquired Harman. That gave them the JBL and AKG brands, as well as the expertise to design the latest Galaxy Buds. Huawei now have their Freebuds. By 2025, Samsung, Apple and Huawei will probably be responsible for supplying around 70% of all smartphones, along with the earbuds to go with them. With their other audio brands, they will probably be taking 90% of the total earbud and headphone revenue. To put it another way, in the space of ten years they will have gone from nowhere to owning that market.

Enter the earbud sanitiser

One other assumption in the model is the life of both phones and hearables. For the purpose of the model, I'm assuming that both are two years. We have yet to see how long users keep hearables and what happens to them afterwards. Whereas phones are sold on, or passed down to other family

members, earbuds are a little more personal. In “The Hitchhiker’s Guide to the Galaxy” [68], Douglas Adams proposed a solution to the over-population of the Earth. It was to build space arks, which would be filled with all the most useless professions, who would be jettisoned into space under the illusion that they were the pioneers to build new worlds. One of those professions was the “telephone sanitiser”. I wonder whether that job description has come true and we’re about to require the service of earbud sanitisers to recycle hundreds of millions of hearables? Otherwise, we could be generating a lot of landfill, particularly as most hearables appear to be almost impossible to recycle or repair, with iFixit scoring them at 0 out of 10 [69]. We also don’t know how often they will lose them and need to replace them, but that will only lift the numbers.

The iOS / Android split

Putting the numbers together, we see sales of earbuds rising to just over 500 million devices by the end of 2025, with the Android share taking the bulk of sales. Apple has probably surprised itself by the number of Android users who have bought AirPods. It’s difficult to know what percentage of sales that represents, but it may be over 10%. That is likely to fall off quite rapidly unless Apple continues to innovate ahead of its new competition.

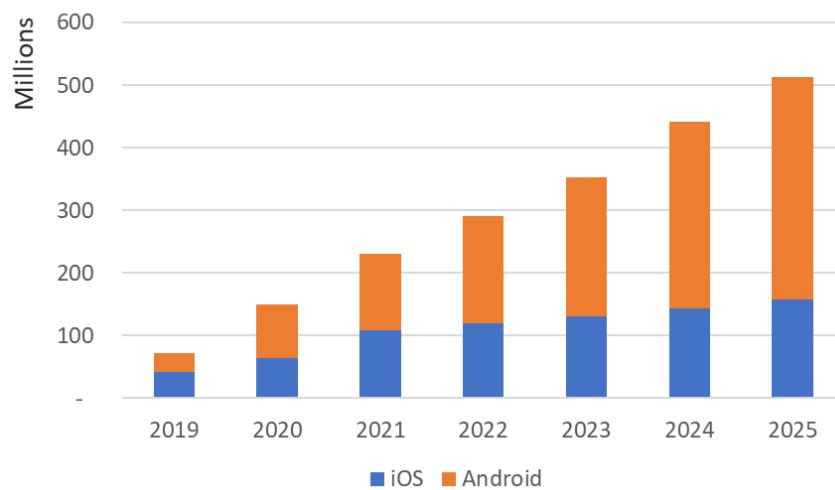


Figure 14. The split of iOS and Android earbud sales

This isn’t the full picture, as there are four other niche categories where users are likely to purchase other brands of earbud to access specific features. These are:

- Voice Assistant specific, such as Amazon’s Echo Buds
- Sports specific earbuds, such as Jabra
- Medical or biometric earbuds
- Translators

Amazon’s Echo Buds are interesting, as they extend the Alexa experience outside the home. We need time to see how that evolves and whether users find it beneficial. Amazon is in an interesting position

of being able to offer users a product which they can subsidise and integrate as part of their Prime community. It's early days for that, but they are probably the only player outside Apple, Samsung and Huawei that is capable of addressing a captive audience of a hundred million or more. One limitation is that voice assistants have remained stubbornly regional, focusing on English and Mandarin speakers, but that's quite big enough for the time being. If they are successful, Amazon may decide to license the technology to other wearable vendors rather than continue to develop their own products. That will be a commercial decision at some point and will probably just shift the sales volumes.

Sports hearables are a nice niche. They target a secure fit, so that they don't fall out in the gym, can utilise some basic biometrics to help direct training through adding coaching functions, and have their own routes to market. Unlike the Amazon Echo Buds, they are often likely to be an additional purchase, where users may already own general purpose hearables.

Although I have largely discounted any opportunity for mass sales of biometrics in the short term, I have factored in a few from 2023, as that probably represents a point where some manufacturers start to experiment.

Translation was one of the big hopes of early hearables startups, but has struggled to get anywhere. Users currently seem to prefer translation apps on their smartphone, or dedicated translators, not least because both give the opportunity to read what is being translated rather than just hearing it. I don't believe they will take any market share and have excluded them.

These niche sector earbuds may be purchased as second devices, or to access other services, so it feels fair to add them to the previous numbers, leading to a total in 2025 of just under 600 million earbuds.

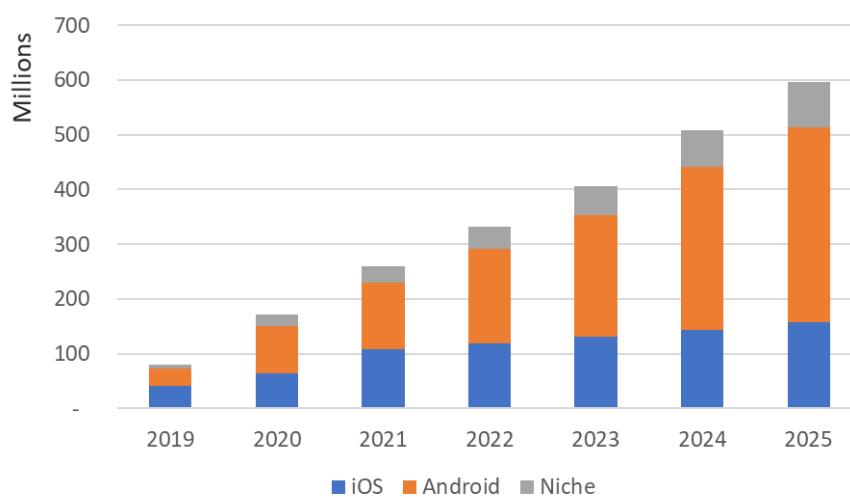


Figure 15. Projected earbud sales

The market pricing for earbuds has very much been set by Apple. They are still the market leader, often being in the happy position where demand exceeds supply. They have managed to hold the original price of \$159, successfully raising it to \$199 for the second generation with wireless charging and to \$249 for the PROs with ANC. If you visit electronics stores in the Far East you'll find cabinets

full of competing earbuds from every audio brand, ranging from \$50, up to \$350 and more for high spec devices, but the AirPods are the ones you see on the street. Samsung, Huawei and Amazon are aiming at the \$100 mark and seem to be holding that, although each of them will probably bundle them for less with their phones or services. Samsung have already offered their new Galaxy Bud 3s free for people pre-ordering top-end phones. But on the whole, branded products are also holding their price.

Then there is China, where there is much more evidence of non-white, non-AirPod devices nestling in ears. There are certainly a lot of cheap earbuds being produced. Visit any major industry trade show and you'll see booth after booth of Chinese manufacturers offering earbuds in every conceivable colour from a little as \$5 a pair. Noise cancellation starts at \$10. Broadcom and Qualcomm are obviously doing an excellent job of selling their new chips and some of the cheap earbuds sound a lot better than you would expect. It's difficult to gauge exactly how many of these will be purchased. At that price they almost become disposable. However, although they may boost the overall numbers, they will add little to the overall market revenue.

The difficult question is determining where pricing will go over the next six years. Apple aficionados will probably continue to be happy to pay full whack, because that's what they've been trained to do, although I think the PRO will struggle to maintain its premium. If Samsung and Huawei deliver on audio quality (and Huawei is winning awards for theirs), they should be able to stay around the \$75 - \$100 mark. Brands which can differentiate in niches will also hold their price. But if any of the big brands step out of line and start to commoditise, prices could tumble. I'm inclined to think that won't happen before the end of 2025. Now that phone vendors dominate the market, they will want to do their best to keep the high margins they're seeing from hearables, particularly as they enter the uncertain world of 5G handsets. Earbuds have become something of an unexpected golden egg for them, which they won't want to give up.

Industrial hearables

In the previous report I included industrial headsets. Looking at the market, there have been some interesting developments, but most of the demand is for devices which can monitor and record an employee's exposure to noise. Whilst the technology in the headset is very similar to that of consumer hearables, it needs to be complemented by back-end systems which record and analyse the hearing data, so that employers have confidence that it is a valid record. This means that deployments generally go through multiple pilots and trials, leading to much longer adoption cycles. For that reason, I'm no longer including them in these figures, as the market dynamics are so different. It is a sector which remains a major opportunity, but has other challenges to meet, specifically how to record and monitor exposure for employees. It will be a significant market opportunity, but will take time to develop.

Wireless headphones

This brings us to wireless headphones, which looked straightforward until the AirPods came along. Back in 2016, consumers were falling in love with wireless headphones, as evidenced by the growth shown in Figure 3. Everyone was predicting CAGRs of 15 – 20% for the foreseeable future. Nobody really thought that users would turn their backs on them in favour of earbuds.

Not only did that happen, but the audio quality of earbuds has progressed far faster than most would have imagined. They have noise cancellation and with the new generation of MEMS speakers should be able to provide an audio range to match headphones. It means that users need to justify the additional cost and size of headphones compared with earbuds and that equation is looking increasingly less favourable for headphones. They will always have their advocates, but as we have seen with music streaming, the majority of the market goes with convenience.

Perhaps an even bigger issue will be the social implication of isolation which we touched on in the psychology of earbuds section. Wearing a pair of headphones is a much stronger sign of detachment than wearing earbuds. Taking them off looks like an effort, which can easily be interpreted as resentment. In comparison, slipping out an earbud is effortless. Such a small perception could very easily become fixed in people's minds and determine the future of headphone sales. All of a sudden, headphones are beginning to collect negatives.

In the short term, the wireless headphone market will continue to grow, albeit slowly. Companies like Beats, JBL, Bose and Sony have strong brands. But by 2020 wireless headphone sales may have peaked, with their future being a return to a more specialised audiophile market, where most will be a secondary purchase for earbud owners.

Hearing aids

The hearing aid industry is working hard to break down the stigma associated with wearing hearing aids. Connectivity to phones is improving, with Apple's MFI protocol and the new ASHA standard on Android 10. Once the new Bluetooth standard is implemented in handsets, connectivity to phones should become universal.

Even without other changes to the user perceptions of hearing aids, this should increase the number of sales, not least as more people already using wireless earbuds and phones become part of the hearing loss demographic. Two other factors should help the industry accelerate the market.

The first of these will be the new connectivity options from Bluetooth, primarily the ability to connect to TVs. That's a step change for accessibility, which is probably far more important than to many potential users than phone connectivity. The second will be the impact of OTC and similar schemes. Not only should that ease of access increase sales, particularly in the US, which has a lower than average use of hearing aids, but it is also likely to increase the number of companies joining the hearing aid industry, spurring competition. If wireless headphone sales falter, the hearing aid market may appear to be a very attractive alternative market for those vendors. Bose has already made that commitment.

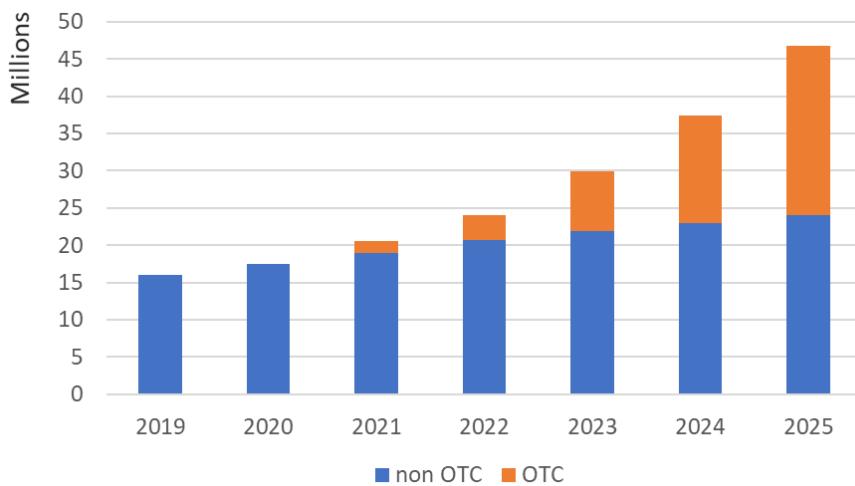


Figure 16. Sales of hearing aids 2019 – 2025 (millions of pairs)

New entrants into the hearing aid market need to be aware of the amount of IP owned by the existing players. Patents are used as effective entry barriers in most sectors of the medical instrument industry, and hearing aids are no exception. As other sectors get squeezed, hearing aid companies are likely to use them to defend their market.

The global market for hearables

Putting all of the numbers together gives us a projected figure of just over 630 million hearable products in 2025, predominantly pairs of earbuds. To be absolutely clear, all of these numbers refer to stereo pairs, not individual earbuds or hearing aids.

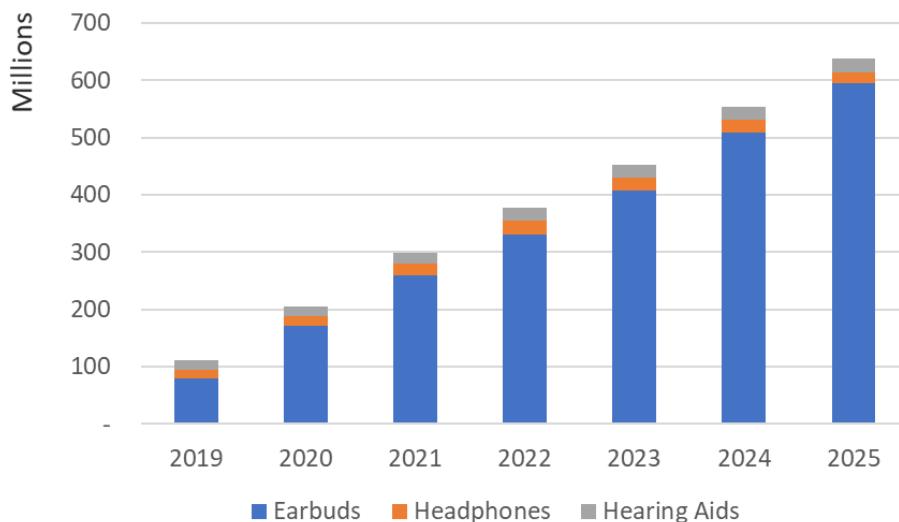


Figure 17. Global sales of hearables 2019 – 2025

To put that in context, it's still only half of the estimated sales number for smartphones in 2025,

which are predicted to fall to 1.248 billion.

When the revenue is calculated, it gives us a total market size of \$80 billion in 2025.

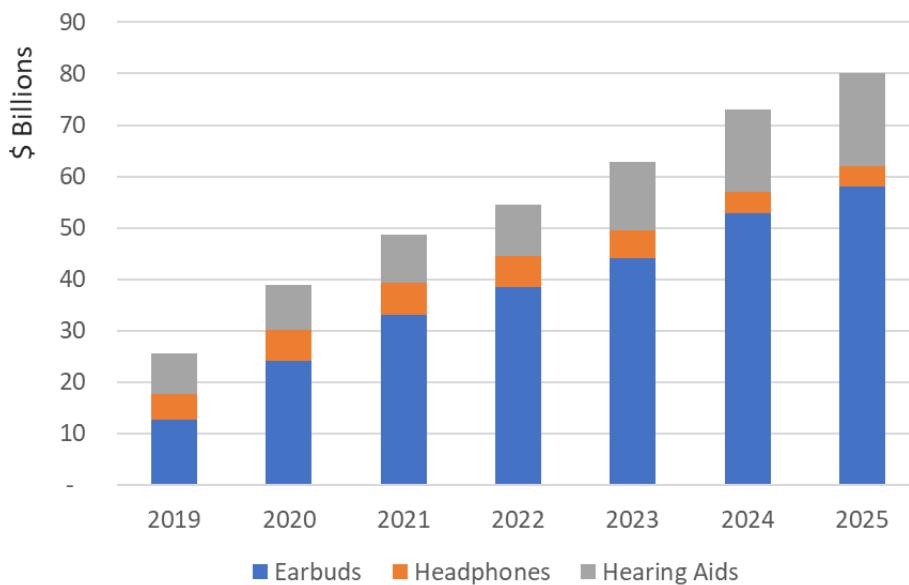


Figure 18. Global market size of hearables 2019 – 2025

Earbuds continue their stunning growth, slowing only slightly as we approach 2026. Hearing aids, bolstered by easier availability, reduced stigma and renewed competition will grow strongly, largely due to the increase in market size as more users accept them. The casualty is likely to be headphones, unless they can persuade us that they are cooler than earbuds.

The hearing aid revenue is calculated on wholesale prices, so does not include any audiology services which are normally part of a purchase price. That's because of the uncertainty of the business models and margins which will emerge as the new OTC regulations change the way they are sold. Nevertheless, it shows very attractive growth.

Where are the audio funds?

As an afterthought, with a market value of \$80 billion, it seems rather strange that there is no VC fund targeting the sector. Although it looks as if earbuds themselves will be dominated by the leading smartphone manufacturers, there is massive innovation in the technology going into them, particularly in sensors, transducers and audio algorithms. We're still seeing a lot of enthusiasm from users to support new crowdfunded wearable projects, indicating that there are still plenty of new ideas which need to be developed and tested before entering the mainstream. There's been a surprising amount of M&A activity within the sector, from the unicorn exits of Beats, Cambridge Silicon Radio and Harman, to a string of smaller, targeted acquisitions amongst component suppliers.

Whatever VCs and investors are listening to, it doesn't appear to be the excitement of this market. Maybe it's time somebody gave them some better quality hearables.

Conclusion

Writing this at the turn of the year and looking back at a potential market revenue of \$25 billion in 2019, it feels odd to think that the market barely existed in 2013. A few headphone manufacturers were shipping a couple of tens of thousands of wireless headphones and that was about it. The growth has been extraordinary.

Over those past six years the market has changed. Earbuds are the must-have product. Unusually, the initial technical specifications and usage expectations for the products were almost all set by crowdfunded start-up companies. However, over the next few years the top three smartphone manufacturers have taken over the market, threatening most of the established audio consumer brands.

Looking forward, the hearing loss market looks particularly exciting. Earbuds could erase the stigma that has surrounded hearing aids for the last half century. That will increase the potential customer base by a factor of ten or more, something that excites both the hearing aid industry and other audio manufacturers who see the opportunity to pivot their business away from the competition of the smartphone vendors.

The new Bluetooth audio standards provide the ability to change the way we consume and use audio. They're not just a better way of doing what we do today with music or phone calls, but they allow us to share audio, combine voice and music and interact with the spaces around us. If the various visions of people retreating from visual overload are true, that may change the way we interact with each other and potentially affect the future evolution of smartphones.

We do need to understand more about our addiction to music. Self-induced hearing loss is hitting us at an ever younger age, and it's important that we don't blind ourselves to the damage that can be done. The industry needs to ship products responsibly and put more effort into understanding the consequences of the behaviour that these products engender. Unless it does, it may find the hearables opportunity regulated away from it. Equally, the industry has the potential to safeguard our hearing and perhaps help us to quieten our world. Initiatives from organisations like Mumbli and the Good Hearing Initiatives are examples of using technology positively. Their emergence provides hope that the prospect of a \$80 billion dollar market will enhance our audio experience, rather than just push out more tech. That's important, as the services market behind hearables is probably as large, or even larger. If we can make hearables work well, then both should benefit.

Nick Hunn

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Nick has been closely involved with the Bluetooth SIG, the Continua Health Alliance, the ZigBee Alliance and other medical, smart energy and standards groups. He is the author of “The Essentials of Short Range Wireless” – a book attempting to explain the application of wireless technologies to product developers, and is currently writing books about the use of the new Bluetooth Low Energy audio standard and designing for the Internet of Things.

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