

The Evaluation of Hardware Components Within the 3D Audio Market

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I. INTRODUCTION

As developments in psychoacoustics, 3D and spatial audio are being propelled, it is important for consumers to know who they can trust for reliable information. This paper will explore two key aspects of the market; firstly, assessing the advancements in spatial audio playback, such as headphones and speaker arrays, then secondly analysing 3D audio software used for playback, such as Rondo360. Research into this industry emphasises the bias in favour of businesses own developments; highlighting the difficulty of finding reliable answers for consumers. Thus, providing importance into this evaluation of the spatial sound market for objective and critical analysis, which consumers can apply when deciding what hardware to purchase. This objective has already been attempted by others such as Hooke Audio founder Anthony Mattana [1]. Although providing validity in its recency, their investment within the industry may provide bias in their evaluation and lacks critical analysis; supporting the need for this evaluation to further enhance public knowledge of spatial audio. This paper will use mostly secondary research published by these companies, whilst being cross referenced and validated by primary research using these products first hand. However, accessing unbiased secondary research from companies own websites is difficult, with primary research during nationwide lockdown also being hard to access.

A. History

The initial recording systems were developed in the 1800's, with Thomas A. Edison being the first to attempt replicating accurately the sound of a recorded space using more than single channel systems (mono). In 1958, the first stereophonic recording was produced, built on Alan Blumlein's research of using two microphones and speakers for stereo reproduction [2]. Oxford mathematician Michael Gerzon develops this research further in 1973 with Ambisonic theory; "a method for recording, mixing and playing back three-dimensional 360-degree audio" [3]. Today, technologies such as Dolby Atmos and DTS: X dominate the commercial market with sound systems being able to play spatial audio in cinemas and homes [2]. As this industry grows, many new rival businesses are attempting to become future pioneers of this industry; proposing to deliver superior sound and software within the 3D audio market, with Hooke Audio believing "the 3D audio space is heating up" [1].

B. 3D Audio Market and Statistics

Market analysts such as DMI predict "the global 3D audio market is expected to grow at a CAGR of 16.5% during the forecasting period (2020-2027)" [4]. They believe "we are witnessing the start of an audio revolution that is changing the future of how we hear and listen" [4]. This is validated by Fortune Business Insights who also forecast a similar CAGR growth stating; "The global 3D audio market size

stood at USD 3.80 billion in 2018 and is projected to reach USD 12.97 billion by 2026, reflecting a CAGR of 16.9% during the forecast period" [5]. Validation provided by industry professionals and market analysts aids in supporting the relevancy of this paper; as this cross referenced data indicates more consumers are predicted to invest in this market, and so will need access to reliable evaluative information about the 3D audio market. Fortune Business Insider believe "the growing implementation of 3D audio in numerous applications of the gaming industry is one of the key factors expected to drive the growth of the market during the forecast period"; arguing its growing application within other industries is indicative as to why this market is growing so rapidly. This is supported further by Dolby CEO Kevin Yeaman, who believes the key market driver to be the demand from other industries such as game, film and television, who are rapidly producing content for 3D audio hardware; "as the number of Dolby Atmos devices increases, we have also seen the amount of content for these devices continue to grow - we now have over ten partners streaming Dolby Atmos content, with a combined availability of over 1,200 pieces" [6]. This growth of 3D audio content by Yeaman can be validated by Kevin Hilton who states "Netflix now claims over 200 hours of Dolby Atmos material" [7]; providing explanation as to both the growth of the 3D audio market and the content produced for such hardware components.

II. EVALUATION OF SPATIAL AUDIO PLAYBACK DEVICES

It is important to critically evaluate the devices in which we hear spatial audio; something which replicates the spaces sound, such as headphones or speakers, most accurately often is most desirable. Hooke Audio founder, Anthony Mattana, provides a web article, "updating it monthly as new companies enter the space" [1], highlighting the most prevalent companies within the industry; "to help you all keep your finger on the 3D Audio pulse" [1]. This analysis of playback devices aids in identifying significant companies within the industry; highlighting this articles relevancy for the basis of evaluation. However, its lack of critical analysis does debate its importance within this paper.

This research by Mattana has influenced this paper by identifying which playback devices to evaluate; trusting the opinion of Hooke Audio due to their experience within the industry. It has also highlighted the lack of critical analysis found in existing research of this field; influencing this paper by evaluating what these web articles have missed, such as only describing features of hardware, not including the benefits or how they can be improved. Hooke Audio concludes four playback devices are sufficient enough to be included within their web article, including; the Sound One headphone module, Waves Audio NX and Yarra's 3DX. This paper will evaluate these three devices using cross referenced secondary research by other industry professionals.

A. Sound One Module

3D Sound Lab's Sound One Module claims to be "the first accessory that can be simply fixed to any headphone to allow immersive 3D audio experiences" [8]. Research identified an article by AudioXpress in 2016; an online audio magazine who often review similar products. It can be argued this article lacks in validity due to being outdated; with potentially more advanced technology being released since this article. However, their experience within the industry does provide a professional opinion on the product, which can aid alongside customer testimonies to strengthen the evaluation of this product. Although they are experienced in this field of reviewing audio playback devices, it could be debated that due to their lack of knowledge in the process of making these devices, their perception of this device could be less valid than those who make similar playback devices. Another potential issue with this research source is the reader does not know if this is an article paid by 3D Sound Labs to advertise their product, if being so, would drastically reduce the validity of this article for evaluation. This argument is only strengthened by AudioXpress' lack of clarification for either argument. However, AudioXpress has also reviewed a rival product by Hooke Audio which does provide validity to their article for evaluation of the Sound One Module. The article references 3D Sound Labs, stating the module "includes 9 axis motion sensors, Bluetooth Smart connectivity, and a rechargeable battery for up to 18 hours, using a micro-USB connector for charging. The module adds only 13 grams of extra weight to any headphone" [8]. Stating these features allows the consumer to compare this module with rival devices, such as the Waves NX Head Tracker. However, the article does not provide any benefits of these features, presuming interested buyers know what these mean; isolating novice buyers who need this information most. To support this, the article does not provide primary research by demonstrating these features but instead presumes the company is telling the truth, providing an example to how this article can be improved.

B. NX Head Tracker

Waves with their similar product, being NX Head Tracker, "tracks your head movements in order to augment the immersive spatial audio experience created by Nx technology" [9]. Research identifies an article by Matt Vanacoro; a musician who produces reviews for Ask.Audio on audio playback technology. It can be inferred the article to be reliable due to the sources experience within the field as he has reviewed similar products. This is strengthened by his consumer perspective; arguing the article to be unbiased as he is not affiliated with the creators of the device. Vanacoro states "I used the NX with several pairs of headphones and didn't even notice the device physically when the headphones were on my head" [10], this not only provides a strength for the product being comfortable, but also that the source has used it himself. This increases the

articles reliability as it is primary research provided by the source; highlighting the increased credibility of this research compared to AudioXpress who did not provide first hand experience with the product. Vanacoro argues the NX Head Tracker is "priced right to allow for any studio to benefit from 3D Audio" [10], inferring that the device is accessible to everyone due to its affordability, being \$99 [9]. This is competitively priced with the 3D Sound Labs Module, costing the same; demonstrating the amount of choice consumers have and so providing strength to the relevance of this paper, as it may be daunting to choose due to their similarities; being their features and price. From the perspective of this source, it appears the NX Head Tracker is "a proven win" [10], due to its "long battery life, simple to use and unobtrusive design" [10]. Cross referencing this source provides further validity to these claims as Waves also infers to its unobtrusive design, stating a benefit to be its "freedom of movement" [9]. Comparing to the previous source, it can be inferred the NX Head Tracker to be superior due to the lack of praise in the previous source for the 3D Sound One Module. However, it could be argued AudioXpress provides more reliable data as they provide clear figures on the features of the device. For example, 18 hour battery life and only an extra 13 grams to any headphone. Consumers rely on these figures to directly compare devices and so makes the NX Head Tracker from this source less accessible to comparison; reducing its validity. However, Vanacoro provides first hand experience, which when researching a product, is valuable information as It can be argued the opinion of those who have used a product is more reliable than reading statistics from a product page. Vanacoro's source could be improved however by including other perspectives, or a video demonstrating his use of the NX Head Tracker to increase the reliability of this source.

C. Yarra 3D Soundbar

Audio company Yarra claim their 3D audio soundbar to be "the most advanced 3d audio system in the world" (Yarra, 2019), providing "the same immersive entertainment experience as multiple speaker home theatres and 3D audio headphones" [11]. Compared to previous sources, the Yarra 3DX is the latest technology in spatial audio playback. This can offer an advantage over the other devices as it has the potential to provide superior sound quality due to its recency. However, these claims come from Yarra themselves and so would need cross referencing for validation, as they may be biased in their perception of the product; reducing the sources reliability. The source does provide consumer testimonies in favour of the 3DX, but it cannot be guaranteed these to be true and they have not provided reviews in which do not support their product. Consumers which lack critical analysis may be susceptible to this bias and so purchase a product which is not best for them; this demonstrates the importance of this paper as it evaluates the reliability of the research accessible within the

3D audio market, allowing consumers to make an informed decision. Another concern for this product is due to its presence on Kickstarter; a website which allows consumers to pledge money for an idea or prototype to support the company to create it. It cannot be guaranteed this product to ever be fully released to the public. However, Yarra have surpassed their goal of \$50,000 with \$738,184 and have 1,848 backers supporting their product, this amount of support provides testament to their product, demonstrating its popularity within the audio community. Yarra highlight some of the disadvantages using previous products such as the NX Head Tracker and 3D Sound One Module provide; “Transaural 3D audio provides two critical elements that have been missing in traditional headphone delivery: accurate sound field modelling and “outside your head” localized sounds” [11], providing benefits of their product over the competition, allowing consumers to make the right choice when choosing a spatial audio playback device. However, when compared to previous sources not affiliated with the product and demonstrated their experience with it, it may be inferred this information to not be as valuable due to its potential bias. Yarra describe some benefits of the 3DX soundbar to be “Dramatically enhanced sound spatialization, highly accurate sound field modelling, situational awareness using 3D (X,Y,Z) audio worlds and natural immersive listening without headphones” [11]. Cross referencing this source strengthens these claims and provides further reliability for the company. User Gactm highlights their experience with the product compared to 3D headphones on Av Forums, “the 3D surround sound effect of the headphones was somewhat confined inside my head... Yarra produced a totally different 3D surround sound effect. The sensation was that the sounds were somewhere above and around my head” [12]. Not only does this strengthen Yarra’s claims of their product, but due to Gactm’s lack of affiliation and experience with the 3DX soundbar, provides a reliable source to support the product. The inclusion of this soundbar within this report compared with 3D headphones provides further options for consumers who desire that “outside your head” [11] sound. Allowing this evaluation of spatial audio playback to be accessible to all consumers; demonstrating the relevancy of this critical evaluation of online reviews and hardware components within the 3D audio market.

D. Evaluation of Papers Methodologies

The evaluative work within this report arguably is similar to current research within this field as the rating of playback devices has already been done. However, this paper builds on previous research as it provides unbiased critical analysis of pre-existing reports; improving this area of research for consumers.

It is important to identify research methodology issues within this report to highlight areas in which can be improved, being the lack of primary research and experience with these products first hand. Without these key aspects,

this report must trust and presume the reviews in which the companies publish are accurate; identifying a disadvantage of this evaluative paper. However, cross referencing data does mitigate this weakness.

Overall, this evaluation of these spatial audio hardware components within the 3D audio market is important as it highlights the bias and shortcomings of pre-existing reviews and analysis of these devices; allowing consumers to make informed decisions based on an unbiased and critically analysed evaluation.

III. EVALUATION OF 3D AUDIO SOFTWARE ENGINES

To achieve spatial audio recording or playback, computer software must be used and so it is important to identify which one is most effective. Software review company G2 highlight their emphasis on providing “authentic reviews about thousands of software products and professional services” [13]. Research within their site has identified a comprehensive list of the best audio software engines, including various criteria in which they believe must be met to be included in their recommendations; being to “provide a prebuilt framework for audio management, integration with outside audio engines and offering authoring tools to create adaptive, dynamic audio” [13]. This pre-existing research directed this evaluative report by identifying the highest rated audio software considered by consumers, providing relevancy for this report to aid in pre-existing evaluation of 3D audio software and playback devices and the research surrounding these hardware components. This research has influenced this paper in which software is worthy of evaluating and taken inspiration from G2’s research methodology to aid in this critical analysis. G2 categorise their reviews of audio software by evaluating these key criteria; “amount of feedback provided in the review, attribution (Did the reviewer keep their name and company public), whether the reviewer is a current user of the solution (Included a screen shot) and community engagement with the review” [14]. This report will replicate these aspects for evaluating whether the review is trustworthy and relevant for critical analysis. G2 conclude Timber3D’s sound engine Sfera to be one of the most favourable software engines in terms of popularity and ratings within the community. This report will critically analysis this engine whilst evaluating the reliability of the research of this software, alongside the next highest rated engines; being DearVR and Rondo360.

A. Sfera

Sound technology company Timber claim “Sfera is the most advanced 3D audio engine that gives you absolute control over the position and movement of any sound and allows you to simulate reality” [15]. This source of research was created by themselves for their website. They are a company who “specialise in immersive, binaural sound sensation” [15] and so are reliable due to their experience within the industry. However, there may be bias in their statements as

they sell this product; reducing its validity. They claim “with Sfera you can position or move any sound around the listener with absolute control, adding a huge degree of presence and spatial depth to the sound design” [15]. To verify these claims by Timber, further research must be cross referenced to increase the reliability of Timber’s product. Sound designer Dave Cooper supports these claims stating, “I was hugely impressed with its capabilities to create a plausible 3D environment compared to other available software” [16]. Cross referencing Timber’s claims is important to consumers who cannot critically analyse statements online, thus highlighting this paper’s importance as it identifies the credibility of research already existing for these products, allowing them to make the right purchase decision.

Timber attempt to reduce bias on their website by including customer testimonies which support their product. For example, Sonus Pro Studio owner Daniel Samaan says; “the Sfera engine is the evolution of true audio immersion, and a complete replacement of surround sound systems” [17]. To have such praise verify Timber’s claims from an industry professional increases the validity of the research source and the product highly. The Sfera engine can be further supported by producer Christian Lobo who argues “for me this is the evolution of sound, the new stereo. In other words, this is the new sound standard that all media should now be delivered in” [18].

When evaluating this research source, one aspect which Timber achieve is their effective description of Sferas features; highlighting what the software does. However, this source of research could be improved by emphasising the benefits of their product as beginner consumers may struggle to understand what features they may need, for example, explaining why “Sfera engine is constantly recalculating the real reflections” is beneficial to them [15]; limiting their consumer outreach. Another aspect which would benefit consumers of this field would be the inclusion of comparison of rival software engines, highlighting the differences of their product. It is the evaluation of these shortcomings which aid in the creation of this paper; identifying the weaknesses of public research sources to improve the already existing market based research of spatial audio software engines.

B. *Ambi Micro*

Software company DearVr has created Ambi Micro which claims to allow sound engineers to “mix, monitor and render Ambisonics tracks right out of the box” [19]. These claims appear from DearVr’s website which raise some issues in validity due to their affiliation with the software and so could be biased in their description of Ambi Micro. Comparing this research source to Sfera, who also make these claims but attempt to verify them through customer testimonies, highlights an aspect where DearVr could improve their reliability of their products advertisement. However, an advantage Ambi Micro has over the Sfera

engine is its accessibility to its target audience. DearVr has created a free version of the software which allows the opportunity for wider use, therefore increased likelihood of customer reviews to allow consumers to form an opinion. This feature also allows primary research of the software to be present within this report, strengthening its significance and importance within this field of study. DearVr claim Ambi Micro to allow the adjusting of microphone position, accept multiple Ambeo formats, head tracking for video and to create master audio for YouTube VR and Facebook360. Primary research of these features verified most of DearVr’s claims to be valid; therefore, using experience with the software to increase the reliability of this research source. However, lack of resources, such as a VR headset, prevented the verification of the effectiveness of one of DearVr’s claims; highlighting an aspect which could aid in improving the reliability of this paper on the evaluation of spatial audio software engines. Secondary research strengthens DearVr’s claims further; Sound on Sound article writer Chris Timson validates the features of Ambi Micro by stating; “the DearVr Ambi Micro plug-in takes Ambisonic data as its input, and outputs stereo binaural data. Best of all, it’s free” [20]. Timson not only validates DearVr’s research source, but supports their software stating; “I listened — and it was a revelation. It was as if my head was where the microphone was set up. I could hear and place each musician as they were spread out in front and to the sides. The effect was spookily realistic and quite addictive” [20]. When comparing customer testimonies to the Sfera engine, both appear to receive high praise. However, identifying research uncited by the manufacturers avoids issues of bias; therefore, arguing Ambi Micro to contain more reliable sources of data for the support of their product.

C. *Rondo360*

When identifying credible sources for competing software, Ian Hamilton appears to support Dysonics software Rondo360 who believes it to “streamline the process of building highly immersive audio” [21]. Hamilton can be considered a reliable research source due to his experience within the industry of spatial audio, who is an editor for Upload; a news organisation focused on “the intersection between people and VR/AR (Virtual Reality and Augmented Reality)” [22]. This provides validity to the source due to their experience reviewing this area of the industry. Also strengthening this source’s reliability, is their non-biased consumer perspective alongside Hamilton’s professional background. Comparing these aspects to previous sources such as DearVr, it could be argued Hamilton’s perspective on Rondo360 to be more credible due to his lack of affiliation with the software, whereas DearVr may provide a biased opinion of their product. This analysis, creating further research beneficial to this area of the industry, of already existing sources provides an example for the relevance and importance of this evaluative

paper; as it provides consumers further critical analysis of products they may wish to purchase; allowing them to make an informed decision. An important aspect to consider when evaluating the validity of a source is their experience. It can be argued a source who has first-hand experience with a product to be more credible than one which merely describes what the manufacturer has promised. However, there is credibility in the company's expertise of their product as they have the most experience with it; providing a counter argument for the support of consumer experience. Hamilton's review of Rondo360 provides example to favouring consumer experience as he states, "we tried a version of Dysonics technology...In short, it is a massive upgrade and integral to drawing people into a 360-degree project" [21]. A positive opinion based on experience provided by an industry expert not only provides reliability to the source itself, but for the support of Rondo360 as a worthy software engine for spatial audio. It could be argued Hamilton to have an affiliation with Dysonics due to the lack of negative critical opinion within the review. However, countering this is the comparison of Rondo360 to similar software Steam Audio; "Valve recently purchasing a company that allows it to offer Steam Audio for free to developers creating interactive experiences. Rondo360 is meant more for the creators working with 360-degree videos" [21]; providing example to an unbiased research source and highlighting the importance of critical analysis for consumers to identify what is right for them.

D. Evaluation of Papers Methodologies

The analysis of these software engines within this paper attempts to build on previous research of the spatial audio industry. It is similar to already existing sources due to its feature listing descriptions of the products; identifying what is best for the consumer. However, it differs in the evaluative aspect as previous sources will only highlight some features and benefits, whereas this paper will critically analyse the source itself, evaluating its importance and trustworthiness, whilst comparing products against each other to conclude which is best; providing an unbiased perspective of the industry for consumers to use. However, using secondary research introduces some theoretical research issues which can be significant in influencing any conclusions made within this research report. When citing secondary research, presumptions must be made about the truthfulness of the source. In some instances, primary research wasn't developed to authenticate some claims of products and so hinders the reliability of this paper. There also may be an element of bias when identifying which products were worthy of identifying as they were mentioned due to others recommendations. This may influence the opinions made within this report; altering the perception of quality of these products due to human nature. However, these issues were mitigated by cross referencing sources and providing primary research when possible. This evaluation of spatial audio software engines contributes to this field of

study by providing more extensive critical analysis of existing products which consumers can use to evaluate which product is most appropriate for them.

IV. CONCLUSION

To conclude, it is clear pre-existing research within the field of the 3D audio lacks comprehensive evaluation and unbiased critical analysis. This report highlights the increased perception of reliability from articles unaffiliated with the company's product, compared to the manufacturer's website itself for an opinion on the product. However, when cross referencing sources for the key features of a product are desired, the company's website is usually sufficient in knowing these details. If a consumer perspective is a more valuable opinion, however. This report found the reviews within tech specific websites unaffiliated with the company were most reliable for this information. This report has improved the existing field of study due to its comprehensive critical analysis of spatial audio products and the pre-existing research presented to consumers which they use to purchase these products. This evaluative report of the 3D audio market not only allows the consumer to avoid making the wrong decision; potentially avoiding being influenced by misleading information, but also allows those who cannot critically evaluate information presented to them for reliability to be able to make the right decision regardless.

Between the products compared for spatial audio playback, the Waves NX Head Tracker appeared to be the most desirable playback device. This is due to the overall reliability of sources identified for this product, which gave comprehensive trustworthy perspectives of the device compared to Yarra's soundbar and the 3D Sound One Module, which appeared to be only affiliated with the company. The features of the NX Head Tracker compared to the other devices were superior due to its "long battery life...unobtrusive design" [10] and competitive price, allowing the device to be accessible to all consumers.

Through evaluating the sources identified for the most favoured spatial audio software engine, it appears Dysonics Rondo360 to be the best software engine compared to the others identified within this report. This is due to the high praise received by industry professionals which favoured this software over any other, due to the product streamlining "the process of building highly immersive audio" [21], which is often most desired in this newly developing industry as it can allow easy entry into this industry for beginner consumers.

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