Comparison between Soundman OKM II Studio Classic and Neumann Art Head KU81i in technical and timbral aspects.

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Hypothesis

Soundman products are an inexpensive, mobile solution for stereophonic, binaural recordings. Despite major technical differences between the Soundman OKM and the Neumann KU81i dummy-head, amateur sound engineers hear no difference, and professional sound engineers can not consistently distinguish the Neumann dummy-head from the Soundman OKM via comparison of example audio recordings.

Objective

It will be demonstrated through perceptual experiments, that amateur listeners cannot distinguish between the Neumann KU 81 and the Soundman OKM II Studio Classic and that professional sound engineers have difficulties identifying the Neumann dummy-head in direct comparison. Further experiments will compare technical specifications, such as the frequency response or the distortion factor.

1 Introduction

Should our hypothesis be verified, Soundman OKMs could be an attractive option for average consumers, e.g. for making a concert recording by very simple means. By using the OKMs a consumer will achieve a 3D listening experience when auditioning over headphones. Music is increasingly being heard on headphones, and as headphones become more popular, dummy-head recordings will become more relevant. Also for audio engineers the OKMs could be a flexible and fast alternative if there is not enough time to install a dummy-head or an equivalent recording system. This thesis tries to show whether Soundman OKMs can really offer outstanding quality in the direct comparison with the professional Neumann KU81i dummy-head.

2 Binaural signals

Recordings made with a dummy-head or Soundman OKM microphones are binaural signals. This means stereo signals, which reach the ear drum after already being subjected to diverse changes. These changes are affected, among other things, by the shape of our ear reflections and spatial properties. For optimum reproduction headphones should be used, because during a transmission over loudspeakers renewed changes of signals happen through the human body and the environment. A professional term for ear signals is Head-related transfer function (HRTF).

> This external ear transfer function, the HRTF function, [...] describes the sound transmission from the free-field at one point at the entrance of the ear channel for a certain sound incidence angle[1].

In simple terms, the HRTF $H(f)$ describes the difference between the frequency spectrum which possesses a signal in the free-field $Output(f)$ and that, which arrives in and is processed in the interior ear $Input(f)$. A formula can be made as follows:

$$H(f) = \frac{Y(f)}{X(f)} \tag{1}$$

where $H(f)$ is the transfer function, $Y(f)$ is the output and $X(f)$ is the input.

2.1 Binaural stereophony

The transfer function is used today for the development of dummy-head recordings as well as the development of headphones, and the design of spaces with optimized acoustics. The transfer function also plays also a role in computer game development, where designers try to produce Virtual Reality effects by using HRTFs in order to create immersive audio

[1] Sengpielaudio: Head-related transfer function HRTF

effects. Each acoustic source is treated by a filtering process, from whatever direction it might come. This is caused through our torso, our head and the outer ears. The brain recognizes the filtering and can make out the direction of the sound accordingly. This filtering can be also recorded in the HRTFs. With the information, which the HRTFs contain, a computer programme can calculate and manipulate signals in such a way that they seem to come from a certain direction. This is achieved by calculating the HRTF information with the audio signal. Thereby an average value is used as each human ear filter sounds slightly differently. The following three diagrams (Fig.7) illustrate the different filtering of several left ears with angles of incidence of -90, 0 and 180. The average value, which is used for the HRTF, is represented by the thick white line.

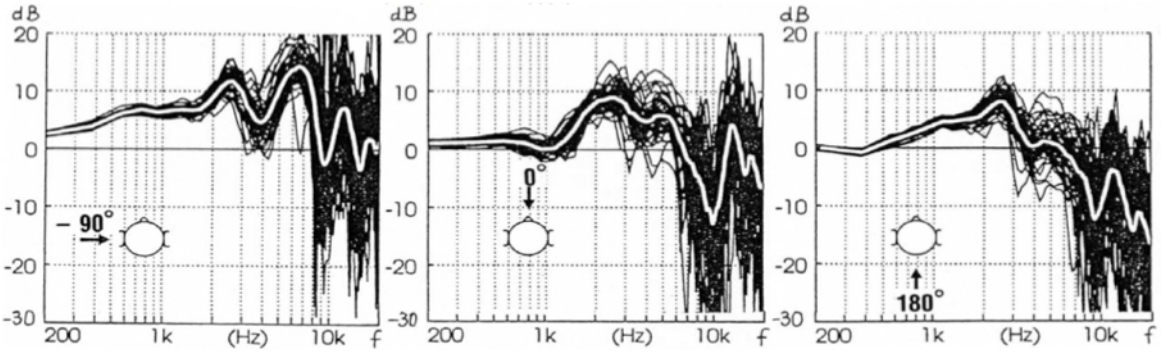

Figure 1: Filtering of several left ears with angles of incidence of -90, 0 and 180 degrees.

2.2 Characteristics of stereophonic binaural audio signals

Stereophonic binaural audio signals allow the listener to enjoy a unique spatial impression listening to the recording over headphones. It is possible to locate signals anywhere in the surrounding area. They can be constituted not only on the frontal transverse level, but also in the back, above and underneath. The panorama and/or acoustic environment also moves around with a head turn (i.e. a listener cannot turn to a noise happening behind him, since it will always remain behind him during a head turn). Since the recorded signals are already ear signals, there will be sound colorations, if the recording is played on loudspeakers. Thus the signals cannot be located correctly any longer.

2.3 Areas of application

Today, binaural, stereophonic recordings are rarely made. This may be partly because of the fact that the initial costs e.g. for a Neumann dummy-head are enormously high.

A further reason could be the inherent limitation of not being able to reproduce the recordings over loudspeakers. Nevertheless, the dummy head is much more able than common microphone equipment to preserve the spatial and directional information of an acoustic sound source and there are several applications for which the dummy-head is used:

- Music recordings - particularly live concert recordings or in acoustically complex areas i.e. churches
- Measurement microphone for the investigation of noise disturbance in the working environment, for industry or city traffic
- Measurement microphone for the acoustic optimization of concert or opera houses
- Measurement microphone for the acoustics of an automated interphone or other acoustic transmission systems
- Measurement microphone for headphones etc.
- Radio plays

With the increasing popularity of headphones, binaural recordings are surely relevant, due to the increasing number of people listening to music using portable devices.

3 Technical Comparison of the two recording systems

3.1 Frequency response in comparison with a measurement microphone

As evident from the technical specifications, microphones transmit different frequency ranges depending on model and manufacturer. This range is specified as 20 - 20000Hz for the Soundman microphone. This corresponds roughly with the human hearing ability. The dummy-head, in comparison, covers a somewhat smaller range. The manufacturer specifies the frequency range as 40-16000Hz. With the Soundman specs the level-differences between left and right channel were supplied, which is below 1dB. With the studio version of the microphones, as they are used here in the project, the inter-channel deviation should not be more than a maximum of 0,5dB in the frequency range relevant for directional hearing. With Neumann KU81i no such data is supplied. Presumably Neumann pays great attention to the channel synchronization of the two microphones during production. We can probably assume that the qualitatively better microphones are the ones to be used for our purposes.

The signal-to-noise ratio indicates the ratio of an information signal (UN) vs the noise level (UG). It is crucial for a subjective feeling of quality and is calculated as follows: 20 x log (UN/UG). The KU81i has with 71dB an above approximately 10dB higher signal-to-noise ratio than the OKMs. Which concludes that the Neumann microphone allows for larger dynamics (particularly for quiet signals) and therefore also has less background noise.

With the maximum sound pressure level, the sound pressure levels (SPL) are specified below. The manufacturer guaranties to adhere to certain distortion factors. With condenser microphones the value is around 120-140dB. This applies to both microphone types. With the OKMs (electret microphones) 125dB are reached, if however, only with the A3 adapter. This data can be confirmed by the author, as during alignment of the recording signals the Soundman microphones without the adapter were clearly more susceptible to distortion/clipping than the KU81i. Within the lower frequency ranges the KU follows the response of the measuring microphone accurately. The OKMs exhibit a considerable boost of bass frequencies. Between 200-1000Hz the curves are almost identical. As compared to the measurement microphones both recording systems show a peak at approx. 1,5kHz. In the further progression the curves follow the measuring microphone more or less, whereby the OKMs are around 3kHz louder within the sensitive range of the human ear (an important range for speech intelligibility). In addition they show a strong drop at 8kHz and the KU-microphones are displaying peaks at 6kHz and 12kHz. The frequency characteristic of the KU then drops towards the end of the frequency range faster than the measuring microphone and the OKMs.

Figure 2: Signal to Noise Ratio of Neumann KU81i vs. OKM

3.2 Criteria for categorization of subjects

We devised questions in the on-line survey in order to categorize subjects according to their experiences with dummy-head recordings, as well as their background/relationship to audio engineering. As on-line questionnaires were distributed over the SAE and specialized forums, one can assume that subjects are predominantly experienced people with audio engineering backgrounds.

3.3 Evaluation of questionnaire

3.3.1 What is your knowledge of recording technology?

34.72% indicate to have no background in recording technology. For 18,06%, audio engineering is no more than a hobby which they exercise occasionally. These amateurs are balanced by approximately exactly the same amount of trained/full-time sound engineers. 34.72% of those being surveyed, are trained sound engineers, who havent started working professionally in the field. In addition, there are 12.5%, which are professional (full-time) sound engineers. As shown later, this information will help in making conclusions with reference to the initial hypothesis of this work. The sound-recording knowledge will be designated in the further process. Group1 are full-time sound engineers, group2 trained sound engineers, group3 amateur sound engineers and group 4 test persons without any audio engineering knowledge.

3.3.2 Localization sharpness (Metronome)

1) In which recording do you find the localization sharpness better?

Here 55.56% of the test persons state that the localization sharpness of the OKMs is better. 33.33% go for the Neumann dummy-head and 9.72% for an approximately equal result. Only one subject feels that the localization is bad with both of them. The preferences for the OKM metronome comes predominantly from the group of trained audio engineers and the test persons without pre-knowledge. Together they constitute 72.5% of the OKM evaluations. People chose the dummy-head almost evenly from all different degrees of knowledge backgrounds. The localization sharpness seems to be independent of the quality of the headphones. So cheap headphones and those from a range of 100-200 are strongly represented. Nevertheless the result is surprising, as the OKMs were worn in the ears of the author during the recording and therefore we are not dealing with generated average ear. Nevertheless the OKMs achieve a better result than the KU81i.

2) In which example do you hear more background noise?

Here 90.28% decide for the metronome recorded with the OKMs. In each case 2 test persons selected the KU81i, equal with both and for I can hear some background noise. One subject does not know what background noise is.

3) In which recording is the environment (ambience) more noticeable?

Slightly more than half of the persons vote for the OKMs. 30.56% go for the dummy-head, 8.33% for both and 2,78% cant hear any recording environment. Six of the nine subjects from group 1 (full-time sound engineers) vote for the Soundman microphones.

4) Which recording is more pleasing to you?

Here 59.72% vote for the KU81i, although the spatial impression and the localization sharpness were more positively evaluated with the OKMs. This is probably due to the higher background noise of the OKMs. The remaining subjects chose the OKMs.

3.3.3 Spatial Envelopment

1) In which recording do you prefer the impression of space?

With 59,72% a clear majority is for the OKMs, compared with 13,89% for the KU81i. 23.61% find the spatial impression more or less the same with both and only 2 test subjects considered this to be bad with both. 2/3 of the group 1 and 2 chose the OKMs. A bit less in group 3 and a bit less than half of group 4 come up with the same answer. The second half of group 4 preferred the spatial impression in both. These are surprisingly good results for the OKMs, since in particular within the group of professional audio engineers many voted for these microphones.

2) Which recording pleases you more?

In this case 70.83% chose the OKMs. Again a higher percentage went for the cheaper microphones with the subjective response. 77% of group 1, 80% of group 2, 69.2% of group 3 and 60% of group 4 select the OKM recording.

3) Which is the recording made with the KU81i?

The distribution of the answers remain almost identical here. Only one person from each of group 1 and 2 changes from the subjective preference for the OKMs to the correct answer.

3.3.4 Intelligibility

1) Which microphones provide better speech intelligibility?

In this example, 44.44% go for the OKMs, 34.72% for the KU81i and the remainder for an equivalent good comprehensibility with both microphones. The preference for the OKMs is likely due the frequency characteristic shown already (i.e. the emphasis of the relevant frequency-range) compared to the KU81i. In groups 1, 3 and 4 the answers are equally distributed or both microphones are approximately judged the same. Professional

sound engineers tend mostly to the OKMs.

2) Which recording do you like more?

As expected from previous questions, the distribution is in this case almost equal. With two abstentions 50% voted for the OKMs and 47.22% for the dummy-head There is no clear tendency from individual groups.

3.3.5 Music Recording

1) Which example needs less sound technical post production work?

The test persons voted here for 76.39% for the OKMs. 16.67% for the dummy-head recording and 6.94% for both approximately the same. It is interesting that 66.7% of the professional and even 84% of the trained audio engineers voted for the OKMs. This indicates a high quality of the OKM microphones. The distribution is similar in the laymen groups.

2) How do you rate the perceptibility of instruments in the space?

With the dummy-head 36.11% perceive it as sound mash without good spatial separation of the instruments. Nearly half of the group 1 and 3 and 1/3 of the groups 2 and 4 feels the same in each case. 20.83% insist that everything is very distinguishable (including 1/3 of the group of 2) and 43.06% can make out a difference between the individual instruments. With the OKM recording however, only 6.94% (including one test person from group of 1) dont perceive a good spatial separation. 65.28% of the test persons believe that the instruments are easily perceived spatially separately from each other. This opinion is shared by 66.7% of group 1, 76% of group 2, 69.2% of group 3 and 52% of the group 4. 27.78% believe that some instruments can be located better than others. This result shows again that the cheaper microphones stand out clearly against the dummy-head

3) Which instrument is most easily located?

The most frequent results here are the guitars. Their spectral content lays within a frequency range which is ideal for human auditory localisation. Also, being a familiar instrument, pre-existing knowledge facilitates source separation.

4) Which recording pleases you more?

Again a clear majority decides for the OKM recording. Only 18.06% prefer the dummy-head recording, vs. 80.56% preferring the OKMs. One person doesnt vote. In the first

three groups the evaluations for the OKMs are in each case over 84%. Only in group 4 a mere 2/3 vote for the OKMs.

5) How often did you identify the microphones correctly?

The answers level off in the middle between two and three of the four examples. 34.72% provide two and 38,89% three correct answers. 11.11% provide one correct answer and 15.28% four correct answers. From group 1 the answers are evenly distributed between two and four. From group 2 there are generally three correct ones.

4 Conclusion

This work brought about some surprising results for me. I would not have assumed that the OKMs could hold its grounds against the KU81i in direct comparison of recordings. Like most test subjects I personally preferred the Soundman OKM recordings in the hearing examples 2 and 4 to those from Neumanns KU81i. It is also interesting to note, that the subjective decisions as in the a-cappella example tend towards the OKMs, where as in the following question (which is the recording made with the KU81i) the test subjects identified the KU81i correctly.
The absolute majority sticks to its subjective opinion, however a few test subjects were consistently able to identify the more expensive equipment. With the issue discussed at the end of the in-front and in-the-background permutations an important point could be established. Test subjects who seem to know the problem of switching between in-front and in-the-background dummy-head recordings seemed to exchange directions more frequently than subjects, who werent aware of this problem. It is not due to the recording system that this confusion arises. Rather, one would need a visual stimulus or a head-tracking system in order to locate the stimulus correctly. This is quite difficult, however, using a simple acoustic recording of signals. It would still be more problematic with impulsive signals, as mentioned before.
It was initially hypothesized that in spite the considerable technical differences between the two recording systems, amateur audio engineers would not be able to recognize differences at all, and that professional sound engineers wouldnt consistently be able to distinguish between the two recording systems. It his a technically more advanced system as compared to the OKMs, at least in terms of manufacturing, i.e. the materials and microphones of the KU81i are most likely of higher quality. As recognized in point 4, however, both systems show strengths and weaknesses in terms of frequency response. Obviously, the KU81i is the qualitatively higher grade microphone, which is also apparent from the data sheet and its market-price of approx. 6000,- Euros.

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