Audio Engineering Society

Convention Paper 10239

Presented at the AES 159th Convention
2025 October 23–25, Long Beach, CA, USA

This paper was peer-reviewed as a complete manuscript for presentation at this convention. This paper is available in the AES E-Library (http://www.aes.org/e-lib), all rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

Perceptual Evaluation of Varied Kick Drum Microphones, With and Without Post-Processing

Matthew Cheshire[1]

[1]*Birmingham City University*

Correspondence should be addressed to Matthew Cheshire (matthew.cheshire@bcu.ac.uk)

ABSTRACT

Microphone selection plays a crucial role in shaping the timbre of recorded kick drums, yet formal subjective evaluations of common kick drum microphones remain limited. This study investigates listener preference for 11 microphones, both in their unprocessed form and after post-processing by three experienced professional audio engineers. All recordings were made under controlled conditions using consistent mic placement and performance. A subjective listening test with 25 participants evaluated each microphone across four listening tests. Results revealed significant differences between microphones in the unprocessed condition, with preferences converging after processing, indicating a reduction in perceptual variations. While processing significantly altered relative preference of nearly all microphones, ratings of two microphones remained consistent across all conditions. Findings also suggest that while processing can elevate certain microphones' perceptual subjectivity, others were found to never be rated significantly different from one another regardless of the engineer's processing approach.

1 Introduction

The kick or 'bass' drum is an integral part of the modern drum kit, which features in most contemporary genres of music. The kick drum is responsible for the pulse of the song as well as being the foundation of the rhythm section, influencing the perceived 'groove' of the track [1, 2]. With an abundance of microphones specifically designed for the capture of the kick drum, either for live or studio recording, the novice engineer may be overwhelmed by choice. Alternatively, the experienced engineer may know the intricacies and differences of the various kick drum microphones at their disposal, selecting a specific brand or model for a certain style, or timbre they wish to create. For this reason, selecting the right microphone is one of the first tools recording engineers can utilise to capture the desired timbre.

Although previous research has been done on subjective microphone comparisons for snare drums [3, 4] and female vocals [5], there is little formal research on subjective differences of varied kick drum microphones. Other kick drum research has instead focused on practical optimisation techniques for live sound applications [6], as well as examining the differences in acoustical output when the resonant head of the kick drum is ported, removed, or left on [7].

Various online articles [8, 9, 10, 11, 12, 13, 14] have conducted kick drum microphone comparisons, often publishing the recordings online, allowing readers to evaluate differences. Although these comparisons are informal and little or no consistency of the playback system is accounted for, useful information can still be gained. For example, the general impression towards

various kick drum microphones, and what timbral characteristics one might expect when using a particular model. In [8], different drum recording techniques were tried and tested from 50 producers, it was discussed that techniques were highly variable and context-dependent, such as combining internal and external mics to capture contrasting timbres, providing additional flexibility when mixing.

An online poll in [9], found listeners preferred kick drum mics with inherent tonal shaping, or "voicing", and least preferred the microphone with the flattest frequency response, offering a neutral, more accurate tonal representation. The authors acknowledge that voiced mics may win in polls because they sound immediately appealing when unprocessed, whereas neutral microphones would benefit from post-processing.

In [10], it was found that each microphone provided a distinct timbral signature, which highlights the importance of selecting a microphone that aligns with the desired sonic qualities. They emphasised consistent microphone placement and volume calibration to ensure fair and accurate comparison of just the tonal differences. Additional, they found that voiced mics with inherent boosted low and high frequencies were more preferred, and lastly discussed using multiple microphone to capture both the low-end "thump" and high-end "click" of the kick drum, suggesting that blending mics can achieve a fuller, more balanced sound.

In all of the online comparisons the samples were unprocessed, to assess each microphone's natural timbre, although in real-world applications, EQ, compression, and other common audio effects would typically be applied. While it is useful to compare the unaltered recordings from the microphones, effects have become ubiquitous in audio engineering, and it is only in very extreme cases where one would not have access to a variety of tools to manipulate and improve the raw sounds. For this reason, in order to simulate a real-world scenario, kick drum recordings from several commonly used microphones will be subjectively evaluated with additional audio processing, thus realising the full potential of any one microphone.

2 Method

2.1 Recording

Microphone selection was based on several of the previously mentioned online articles and reviews, as well as personal recommendations from recording engineers. The final list of microphones (seen in Table 1) was chosen to represent a wide range of manufacturers, spanning several decades of production (1960s—2020s), the inclusion of newer microphones juxtaposed the earlier models, often deemed as classic choices for kick drum recording. One stipulation was that all microphones had to be commercially available at the time of this study. Additionally, a Shure SM58 was selected to investigate how a non-traditional kick drum microphone would perform and to evaluate its potential for subjective improvement through post production.



Fig. 1: Position of the kick drum microphone.

Each microphone was positioned directly in the center of the port as seen in Figure 1, this position was accurately replicated as closely as possible for each microphone. Only three microphones had switchable filtering, these were set such: Telefunken M82 - Kick EQ OFF/High Boost OFF, sE Electronics VKick - Classic/Classic, and Electro-Voice RE20 - HPF OFF. The recordings took place in an acoustically treated studio, which reduced the amount of room reverb. A Focusrite ISA 828 was used for preamplication and an RME fireface 802 audio interface was used for digitization. Gain was set for all microphones to avoid clipping, and recordings were captured at 44.1 kHz 24bit.

Kick-out microphone selection was exclusively focused on. Although any microphone can be used inside the kick drum, the role of kick-in microphone is

Make	Model	Polar Pattern	Type	Frequency	Year
AKG	D112	Cardioid	Dynamic	20 Hz – 17 kHz	1986
Audix	D6	Cardioid	Dynamic	30 Hz – 15 kHz	2002
Beyerdynamic	M88 TG	Hypercardioid	Dynamic	30 Hz – 20 kHz	1962
DPA	4055	Cardioid	Condenser	20 Hz – 20 kHz	2022
Electro-Voice	RE20	Cardioid	Dynamic	45 Hz – 18 kHz	1968
Neumann	U47 FET	Cardioid	Condenser	20 Hz – 16 kHz	1969
sE Electronics	V Kick	Cardioid	Dynamic	20 Hz – 19 kHz	2019
Sennheiser	e602	Cardioid	Dynamic	20 Hz – 16 kHz	1998
Shure	Beta 52A	Supercardioid	Dynamic	20 Hz – 10 kHz	1996
Shure	SM58	Cardioid	Dynamic	50 Hz – 15 kHz	1966
Telefunken	M82	Cardioid	Dynamic	25 Hz – 18 kHz	2013

Table 1: Details of microphones by Make, Model, Polar Pattern, Type, Frequency Response, and Year of Release.

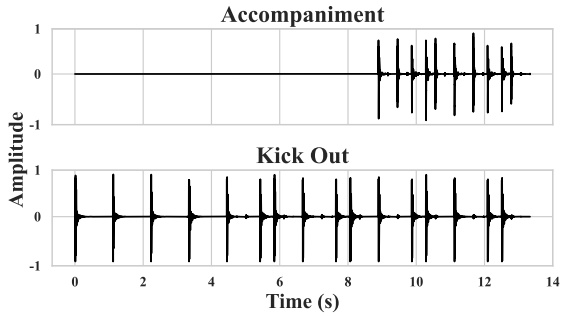


Fig. 2: Waveforms of the audio stimuli used for mixing and listening test. Accompaniment (upper) and the kick-out recording (lower).

typically filled by boundary condensers such as the Shure Beta91A, Sennheiser e901, or sE Electronics BL8 [15, 16, 17]. These are commonly used to reinforce the kick-out microphone by adding more attack due to their closer proximity to the beater, and are seldom used in isolation [18, 19]. Additionally, not all kick drum resonant heads are ported, rendering internal placement impractical in some scenarios. Focusing on kick-out microphones therefore allows the findings to be applicable for both ported and unported configurations. Lastly, larger microphones such as the Neumann U47 FET are often physically too large to be positioned inside the drum via the sound hole.

The stimuli used for the listening test comprised; four isolated kick hits, a 108 BPM two-bar phrase of just kick-out microphone (which naturally included any bleed from the snare and high-hat), and the identical two-bar phrase with the addition of kick-in, snare top, and mono overhead microphones. For kick-in microphone, a Shure Beta91a was used with the contour switch engaged, for snare top a Shure SM57 was used, angled 60° pointing towards the center of the drumhead, and for overhead an single AKG C414 XLS was used, set to cardioid, HPF disengaged, and positioned 140 cm directly above the center of the snare drum. The resultant waveforms of the kick-out drum stimuli and the mixed accompaniment can be seen in Figure 2. The position of all drum microphones was chosen based on the standard practice of recording engineers and various sources [18, 19, 20, 21, 22]. Altering microphone position can emphasise or de-emphasise certain frequencies and resonances of each drum helping to modify timbre. Placing the kick-out microphone directly in front of the sound hole captured a focused signal with low-end emphasis and clear attack, since the air pressure from the drum projects most directly through that opening, whilst avoiding the capture of excesses room ambience resulting from a microphone placed further away. Figure 3 shows the complete set-up of all microphones.

Each individual kick drum hit was peak normalised to remove any slight amplitude variation and then normalised to -23 LUFS altogether. For the two-bar phrase that included the accompaniment, the mix was: Kick-In: -23 LUFS, Snare Top: -23 LUFS, and Overhead: -40 LUFS, the resultant mix was -23 LUFS. As well as removing amplitude disparity between different performances, all recordings were manually quantized to the grid in Pro Tools, further removing subtle timing variations of the drummer.



Fig. 3: Microphone set-up showing kick, snare, and overhead positions.

2.2 Post-Processing

To evaluate the effect of post-processing on microphone preference ratings, three experienced audio engineers were recruited to independently mix the set of kick drum recordings. Each engineer received an identical multitrack session containing eleven isolated kick-out microphone recordings (with order randomised), accompanied by fixed kick-in, snare, and overhead tracks to provide musical context. Engineers were instructed to process only the kick-out channel using their preferred mixing approach, while keeping the processing chain consistent across all recordings. Although processor parameters could vary, the processing chain remained consistent, with flexibility allowed for processor order. Importantly, microphone labels were removed prior to mixing, ensuring that engineers worked blind to the identity of each microphone. Each engineer completed a post-test questionnaire detailing their processing chain, time taken, playback system, professional background, and years of experience. This information is summarised in Table 2. One engineer reported that the "sounds were easy to work with and well recorded. A good variety of choices for different genres of music, all very usable when filtered to taste and genre". None of them reported that any particular samples were easier or harder to achieve a desired results from, and stated that they spent approximately the same amount of time mixing each sample.

The post-processed recordings were loudness normalised using the same method in section 2.1. As the accompaniment was not processed these were left unaltered. Where relative loudness between kick-out and accompaniment had changed, corrections were applied to produce the same perceived balanced as the unprocessed recordings, ensuring no loudness disparity due to the effect of post-processing.

2.3 Subjective Evaluation

The test was conducted using the Web Audio Evaluation Tool (WAET) [23] with the APE interface [24], seen in Figure 4. Twenty-five participants completed the subjective listening test, aged between between 19 to 38 years old (mean 22.96). Participants were asked how many years of experience they have in one of the following fields: audio production, mixing, live sound, recording, mastering, or any role that requires critical listening. Experience ranged from 3 to 17 years (mean: 6.04). All participants reported having normal hearing with no known hearing difficulties or impediments. All participants used the same pair of Beyerdynamic T1 studio headphones in a quiet, noise-free listening environment. The three mixing engineers were not participants in the listening test.

Participants were instructed to: "Rate these samples based on your own subjective preference - Least preferred - Furthest Left and Most preferred - Furthest Right." They could not complete the test until every sample had been played at least once and all sliders had been moved from their initial positions. Each page presented 11 stimuli corresponding to one recording from each microphone. The starting position and slider labels were randomised for every participant and on each of the four test pages. During playback, the play position was maintained when switching between stimuli, and the slider turned from green to red when selected, indicating the currently playing sample. On average it took participants 14m58s to complete all four tests (Unprocessed – 5m46s, Engineer 1 – 3m15s, Engineer 2 – 2m57s, Engineer 3 – 3m0s).

Attribute	Engineer 1	Engineer 2	Engineer 3
Processing Chain	Black Salt Audio Silencer Waves F6 RTA EQ Lindell Audio 80 Series Channel Strip	Three-Body-Technology Kirchhoff-EQ SSL Duality (EQ only) Empirical Labs Distressor SSL Bus Compressor Acustica Audio ASH Acustica Audio LACE	Sonnox Oxford Drum Gate Arturia Comp VCA-65 FabFilter Pro-Q4
Role	Producer/Recording/Mixing Engineer at Magic Garden Recording Studios UK	Recording, Mixing, and Mastering Engineer	Grammy Award-winning recording/mixing engineer
Years Experience	14	10+	25
Time Spent Per Mix	5-10 mins	3 mins	4-5 mins
Playback System	Klark Acoustic Jade One	ATC SCM50	Focal Shape 65 with JBL LSR310S subwoofer

Table 2: Engineer information, processing chain, and playback system used.

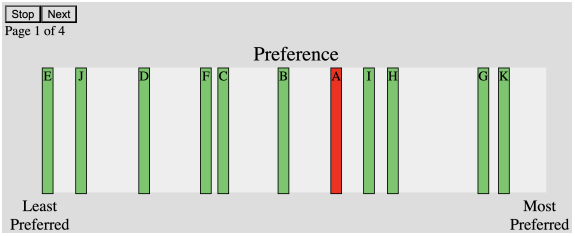


Fig. 4: Interface used for the subjective listening test.

3 Results

Prior to statistical evaluation, box plots were generated for each of the four listening tests, as shown in Figure 5. Microphones are ordered left to right based on their median rating. While statistical significance cannot be directly inferred from the box plot, its inclusion provides valuable visual insights into the distribution of ratings for each microphone. Specifically, it illustrates the spread, central tendency, and consistency of listener responses across both unprocessed and processed conditions. Microphones with narrow interquartile ranges and minimal outliers indicate strong agreement among participants, whereas wider spreads suggest greater variability in perceptual quality.

Before selecting an appropriate statistical test to evaluate the data, several preliminary tests were conducted to assess normality. Firstly, the Shapiro-Wilk test was applied instead of the Kolmogorov-Smirnov test, as it is better suited for datasets with fewer than 50 samples. Secondly, histograms were examined to visually assess skewness, multimodal distributions, or potential outliers. While some microphones exhibited normally distributed ratings ($p \geq 0.05$) according to the Shapiro-Wilk test, others showed significant deviations from normality ($p < 0.05$). These findings suggest that non-parametric statistical tests would be the most appropriate for further analysis.

Given the results of the normality tests, non-parametric statistical methods were selected for subsequent analysis. To evaluate whether there were significant differences in microphone preference within each listening test, the Friedman test was employed. This test was chosen as it is a non-parametric alternative to a repeated-measures ANOVA, making it well-suited for comparing multiple related groups when normality cannot be assumed. Since each participant rated all microphones, the Friedman test appropriately accounts for within-subject variability by ranking the data rather than assuming equal intervals between ratings.

The results of the Friedman test show that for all four listening tests, there are statistically significant differences in microphone preference ($p < 0.05$), meaning that in each test, at least one microphone was rated significantly differently from the others. This indicates a non-random preference pattern among participants. Since results revealed a significance effect, pairwise comparisons were conducted to determine which microphones differed significantly in their ratings.

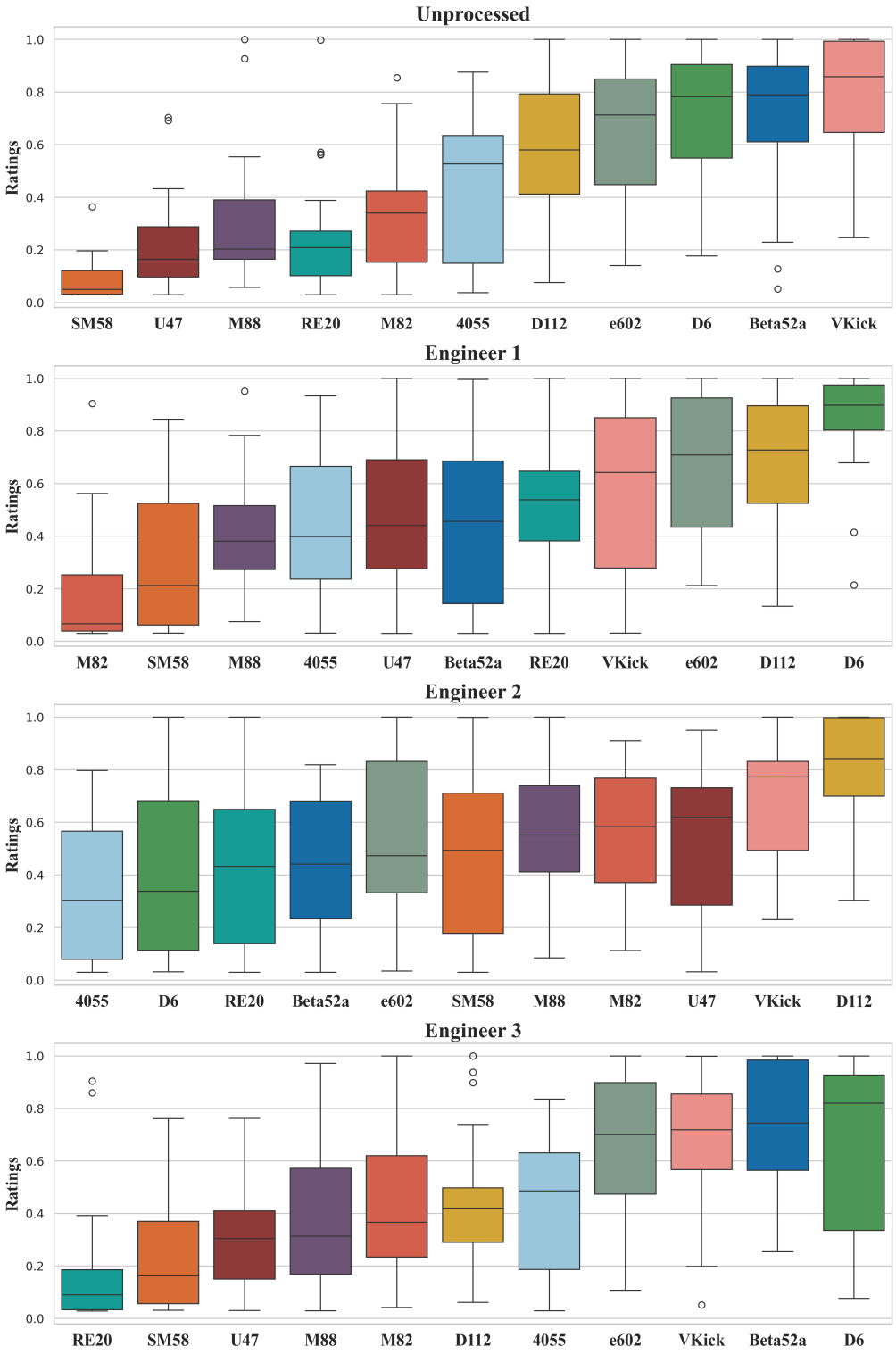


Fig. 5: Box plots of microphone preference ratings across four listening tests. Microphones are ordered by median rating (left to right) within each subplot. Colours are consistent across subplots to aid comparison.

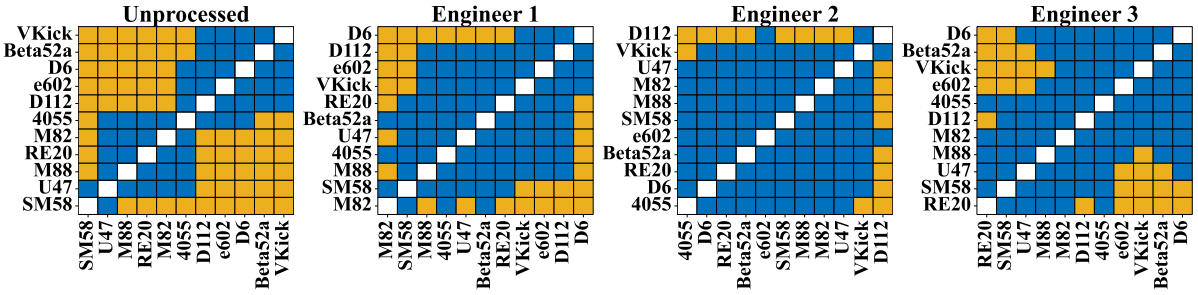


Fig. 6: Pairwise comparisons between microphones based on Wilcoxon signed-rank tests with Bonferroni correction. Yellow indicates a statistically significant difference in scores ($p < 0.05$), Blue indicates no significant difference ($p \geq 0.05$). Microphones are ordered from lowest (bottom left) to highest (top right) median preference rating

Multiple pairwise post-hoc Wilcoxon signed-rank tests were then performed, because multiple comparisons increase the risk of Type I errors (false positives), a Bonferroni correction was applied. This test was selected as a non-parametric alternative to the paired t-test and Mann–Whitney U test. Although the data are continuous, the Wilcoxon signed-rank test remains appropriate when normality cannot be assumed and the measurements are paired, as it accounts for both the direction and magnitude of change within subjects. Unlike the Mann–Whitney U test, which is designed for independent samples, the Wilcoxon signed-rank test is specifically suitable where the same participants rate both conditions, making it the preferred choice in this context [25].

Figure 6 shows the results of these pairwise Wilcoxon signed-rank tests with Bonferroni correction for each of the four listening tests, with microphones ordered by their median score. Table 4 show eight microphone pairs that were never significantly different to one another in any of the four listening tests ($p \geq 0.05$).

In addition, a separate analysis was conducted to examine whether the preference for each microphone changed significantly following post-processing by engineers. Although unprocessed and processed recordings were never directly compared within the same listening test, all stimuli were evaluated by the same participant pool and controlled conditions. This design permits an indirect, within-subject comparison of pre- and post-processed ratings for each microphone. Wilcoxon signed-rank tests were applied to assess whether significant differences emerged across conditions, accounting for both the direction and magnitude of paired differences. Bonferroni correction was applied per microphone to control for family-wise error across the three engineer comparisons. The results of this analysis are presented in Table 3.

4 Discussion

As can be seen in Figure 6 the consistent top-four ranking of the VKick across all four listening tests indicates a potential robustness to engineer variation. Its stable high performance regardless of processing implies that this microphone offers a dependable baseline that remains competitive even after subjective enhancement. The D6 and e602 appeared in the top four across three of the listening tests, suggesting they are slightly more susceptible to processing style.

The unprocessed recordings exhibited the highest number of significant differences between microphones, suggesting clearer perceptual distinctions before processing. The Engineers' processing reduced some of these differences, making certain microphones more comparable in their preference ratings, reducing variation compared to the unprocessed recordings. Engineer 2's processing had the strongest equalising effect, resulting in the fewest significant differences and the most uniform distribution of ratings. For Engineer 2 the only preference shown was for the VKick over the 4055, and the D112 over all other microphones except for the e602 and VKick. Overall, processing consistently reduced significant differences in microphone preference ratings. While the unprocessed recordings had clear distinctions between microphones, no microphone pair remained significantly different across

Microphone	Unprocessed vs Engineer 1	Unprocessed vs Engineer 2	Unprocessed vs Engineer 3
4055	ns	ns	ns
Beta52a	0.003 (↓)	0.000 (↓)	ns
D112	ns	0.012 (↑)	ns
D6	0.001 (↑)	0.000 (↓)	ns
e602	ns	ns	ns
M82	0.001 (↓)	0.011 (↑)	ns
M88	ns	0.001 (↑)	ns
RE20	0.002 (↑)	0.001 (↑)	0.008 (↓)
SM58	0.001 (↑)	0.000 (↑)	0.009 (↑)
U47	0.001 (↑)	0.000 (↑)	ns
VKick	0.004 (↓)	ns	ns

Table 3: Wilcoxon signed-rank test with Bonferroni correction results comparing unprocessed and processed conditions for each microphone. Statistically significant ($p < 0.05$) results are shown with direction of change: (↑) indicates a significantly higher rating for the Engineer, (↓) a lower rating, and *ns* denotes non-significance.

Non-significant Microphone Pairs	
D112	VKick
D6	VKick
e602	Beta52a
e602	VKick
M88	4055
M88	RE20
M88	U47
U47	4055

Table 4: Microphone pairs that were consistently non-significantly different ($p \geq 0.05$) across all of the four listening tests.

all cases after processing, indicating that all engineers' approaches minimised rating disparities to some extent.

When comparing the change in score pre- and post-processing, the results of the Wilcoxon signed-rank test, seen in Table 3, indicate several microphones exhibited significant shifts in relative preference rating following the application of post-processing. It is important to note that these tests reflect changes in relative ranking within the set of microphones, rather than absolute judgments of a microphone's quality before and after processing. A statistically significant result indicates that microphone preference changed relative to others for that condition, not whether the absolute preference of the processed version improved over its unprocessed counterpart. However, it is reasonable to assume that professional processing is likely to improve the subjective preference of a given recording.

Notably, the SM58 was the only microphone to exhibited statistically significant improvements in relative preference ratings following processing for all engineers. Another microphone which had received poor unprocessed ratings, but showed significant shift in relative preference once processed was the U47, improving for both Engineer 1 and 2. Conversely, the relative standing of the Beta52a decreased for Engineer 1 and 2, likely due to its already favourable unprocessed rating. Interestingly, the 4055 and e602, did not experience any significant change in relative preference ratings. It is important to clarify that this does not imply that processing did not improve the absolute preference of these microphones. Rather, it suggests that their relative preference among the other microphones remained statistically unchanged.

One of the most striking results can be seen in the box plot in Figure 5 for the SM58 processed by Engineer 2. Engineer 2's processing increased the relative preference of the SM58 significantly with the ratings covering the full scale (i.e., 0-1) indicating that at least one listener scored this most preferred. This suggests that Engineer 2's processing approach was particularly effective for enhancing the subjective quality of the SM58, relative to the other microphones, showing that it is indeed possible to improve the subjective rating of an unideal microphone with adequate processing.

The microphone pairs listed in Table 4 consistently failed to reach statistical significance in any listening condition, suggesting a high degree of perceptual similarity across both unprocessed and processed versions. This implies that certain microphones may share similar spectral or dynamic characteristics, or at least produce comparably preferred results regardless of the engineer's processing approach. This indicates a robustness in listener perception that may suggest functional interchangeability between these specific microphones in certain recording scenarios when one is unavailable.

These findings highlight the nuanced impact of processing on microphone preference ratings, demonstrating that while some microphones benefit significantly from processing in terms of relative preference, others remain stable. The results further suggest that the effectiveness of processing in altering relative preference ratings is both microphone-dependent and engineer-dependent, with some engineers eliciting stronger effects on specific microphones than others.

5 Summary

This study explored the subjective preference of eleven microphones for kick drum recording, both unprocessed and post-processed by three professional audio engineers. Through a controlled recording setup and blind listening tests with 25 experienced participants, significant perceptual differences were observed between microphones. Post-processing consistently reduced the magnitude of these differences. Eight microphones pairs never achieved significantly different scores across all test conditions suggesting an inherent similarity that withstands different processing techniques. The sE Electronics VKick consistently ranked among the top-preferred microphones across all tests, while no single microphone was found to be rated significantly lowest after processing. These findings demonstrate that while unprocessed microphone choice remains important, post-processing can equalise perceived quality across models to varying degrees.

A limitation of this study is the use of only one kick drum, with constrained tuning, and microphone placement. Future work could investigate how microphone preference generalises across varied mic position, kick drum size, tuning, and performance style. while three professional engineers applied processing to simulate real-world use, their mixes were constrained to fixed accompaniment tracks. Future studies might consider a broader pool of engineers, or allow for mixing the full drum kit to reflect more realistic production contexts.

6 Acknowledgment

The author would like to acknowledge the valuable assistance of Stephen Roessner, Niccoló Conti, Liam Radburn, Samuel Benson, Dan Warren, and Harvey Graham during the course of this research.

References

[1] Owsinski, B. and Moody, D., "The Drum Recording Handbook," *Hal Leonard*, 2016, 2nd Edition.

[2] Toulson, R., "Drum Sound and Drum Tuning: Bridging Science and Creativity," *Taylor & Francis*, 2021, 1st edition.

[3] Cheshire, M., Hockman, J., and Stables, R., "Microphone Comparison For Snare Drum Recording," *145th Convention of the Audio Engineering Society*, (10040), 2018.

[4] Cheshire, M., Stables, R., and Hockman, J., "Microphone Comparison: Spectral Feature Mapping for Snare Drum Recording," *147th Convention of the Audio Engineering Society*, (10263), 2019.

[5] Cheshire, M. and Jones O'shannessy, E., "Microphone Comparison for Female R&B Vocal Recording," *155th Convention of the Audio Engineering Society*, (10679), 2023.

[6] Hill, A. J., Hawksford, M. O. J., Rosenthal, A. P., and Gand, G., "Kick-Drum Signal Acquisition, Isolation, and Reinforcement optimization in live sound," *130th Convention of the Audio Engineering Society*, (8357), 2011.

[7] Gabe, H. and Christopher, J., "Measurement of the Particle Velocity in Front of Kick Drums in Three States," *150th Convention of the Audio Engineering Society*, (10499), 2021.

[8] Senior, M., "Kick & Snare Recording Techniques. Tried Tested Techniques From 50 Top Producers," *https://www.soundonsound.com/techniques/kick-snare-recording-techniques*, 2008.

[9] Rodgers, J., "Kick Drum Shootout - The Results But Do They Really Matter?" *https://www.production-expert.com/production-expert-1/kick-drum-shootout-the-results-but-do-they-really-matter*, 2024.

[10] Fuston, L., "Kick Drum Mic Shootout – with Sound Samples," *https://www.sweetwater.com/insync/kick-drum-mic-shootout-with-sound-samples/*, 2024.

[11] Beam, E., "Massive Kick Drum Mic Review," *https://recordinghacks.com/2012/06/08/kick-drum-mic-shootout/*, 2012.

[12] Waxman, G., "7 Best Kick Drum Mics For Live And Studio," *https://drumhelper.com/audio/best-kick-drum-mic/*, 2025.

[13] Merten, C., "Kick Mic Shootout," *https://soundhouserecording.net/home/blog/kick-mic-shootout/*, 2018.

[14] Wood, L., "Kick Drum Microphones Spotlight Round-up," *https://www.soundonsound.com/reviews/kick-drum-microphones*, 2024.

[15] D'Virgilio, N., "From Kick Drums to Conference Rooms: 7 Best Boundary Mics | Guide," *https://www.sweetwater.com/insync/best-boundary-mics-guide/*, 2023.

[16] Henshall, M., "How to Get a Great Kick Drum Sound Using Two Shure Mics," *https://www.shure.com/en-GB/insights/how-to-get-a-great-kick-drum-sound-using-two-shure-mics*, 2014.

[17] Marie, K., "5 Best Kick Drum Mics," *https://blog.airgigs.com/2023/11/5-best-kick-drum-mics/*, 2023.

[18] Reilly, B., "The Basics Of Miking A Kick Drum," *https://vintageking.com/blog/miking-kick-drum/*, 2018.

[19] Huber, D. and Runstein, R., "Modern Recording Techniques," *Focal Press/Elsevier*, 2010, 9th edition.

[20] Major, M., "Recording Drums: The Complete Guide," *Course Technology*, 2014, 1st edition.

[21] Senior, M., "Recording Secrets for the Small Studio," *Sound on Sound Presents*, 2023, 2nd edition.

[22] Brixen, E. B., "How to Mic a Kick (Bass) Drum," *https://www.dpamicrophones.com/mic-university/how-to-mic/how-to-mic-a-kick-drum/*, 2024.

[23] Jillings, N., De Man, B., Moffat, D., and Reiss, J. D., "Web Audio Evaluation Tool: A Browser-based Listening Test Environment," *12th Sound and Music Computing Conference*, 2015.

[24] De Man, B. and Reiss, J., "APE: Audio Perceptual Evaluation Toolbox for MATLAB," *136th Convention of the Audio Engineering Society*, 2014.

[25] Conover, W., "Practical Nonparametric Statistics," *John Wiley & Sons*, 1999, 3rd edition.