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Living Off-Grid: Exploring the Effect of Quantisation on Listener Perception of Groove in Hip-Hop Music

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ABSTRACT

This study aims to investigate the impact of rhythmic quantisation on groove perception in hip-hop music, focusing on the role of musical experience, listener background, and timing deviations. Groove ratings were assessed for quantised and unquantised variants of hip-hop tracks. Results showed that musicians demonstrated a greater sensitivity to timing variations, preferring slightly off-beat rhythms that enhanced groove without becoming imperceptible or overly extreme. Non-musicians, in contrast, favoured fully quantised rhythms, indicating a lower tolerance for rhythmic deviations. Additionally, while both hip-hop and non-hip-hop listeners showed similar trends in their groove ratings, non-hip-hop listeners provided higher overall ratings, potentially reflecting a more critical ear among hip-hop listeners due to greater familiarity with the genre. All groups agreed that excessive rhythmic deviation diminished the groove, highlighting a universal threshold for timing variations. No significant differences were found between male and female participants. This research provides insights into how musical training and genre familiarity influence the perception of groove and the role of microtiming in creating a dynamic and engaging musical experience.

Key words: quantisation; groove; microtiming

1. INTRODUCTION

Quantisation is a process used in music production to align the timing of notes or beats to a fixed rhythmic grid. By correcting slight timing imperfections during performance, quantisation ensures that these elements conform to the intended tempo or structural framework, resulting in a more polished and synchronised sound (Morrison, 2021).

Defining 'groove'. To explore how quantisation influences groove perception within music, it is essential first, to establish a clear definition of 'groove.'Abel (2014) conceptualises groove as the interaction between individual parts of the music, particularly the rhythm section, that collectively create a unified rhythmic effect. Similarly, Greenwald (2002) highlights the centrality of percussion in establishing the groove, such as the bass drum reinforcing the downbeat and the snare emphasising the second and fourth beats. These rhythmic patterns play a particularly dominant role in shaping the groove in hip-hop.

Groove is often associated with the 'swung' rhythms of jazz or with irregularities such as syncopation and microtiming deviations (Danielsen et al., 2023). However, an alternative perspective emphasises repetition and structural order as defining features of groove. Horner and Swiss (1999) describe groove as the rhythmic feel produced by a repeated framework within which variation occurs, while Tamlyn (1998) argues that groove arises from a sense of comfort derived from rhythmic consistency. These insights suggest that both precise repetition and subtle rhythmic variations contribute to the perception of groove. This provides the basis for assessing how listeners perceive rhythmic and microtiming deviations, which play a central role in the context of hip-hop. Although the use of quantisation may seem at odds with the rhythmic irregularities traditionally associated with groove, it offers a controlled way to investigate how microtiming deviations influence listener perception. By exploring variations in the placement of percussive elements, this study examines how changes in rhythmic consistency affect the perceived sense of groove in hip-hop music.

Literature review. Winquist (2024) conducted a study comparing quantised and unquantised drum and bass recordings to assess the impact of quantisation on groove perception. Data was collected through participant surveys in which musicians listened to paired versions of tracks—one quantised and one unquantised—and indicated their preference between the two. The findings indicated that quantisation did not enhance groove perception, and, in some cases, even diminished it.

A key limitation of Winquist's study was the presence of order effects. Participants were exposed to both the original and quantised versions of the same tracks, allowing for direct comparisons, which could have introduced bias into their responses. Our study addressed this by ensuring that no participant listened to more than one version of the same track, thereby eliminating the potential for comparison bias. Winquist's study also exclusively involved musicians, presuming that their expertise and familiarity would make them more attuned to groove. This overlooks potential differences in groove perception between musically trained and untrained participants (Nguyen et al., 2022). Our study addressed this gap by including a more diverse participant pool, enabling us to explore how musical background influences groove perception. Furthermore, our participant categorisation avoided the arbitrary baseline of one year of musical experience used in Winquist's study, instead employing the Gold MSI (Müllensiefen, 2014), which offered a more flexible approach and better captured the varied levels of musical experience within our sample.

Winquist's selection of tracks by well-known artists introduced bias, as musicians familiar with these artists might have anticipated the use of microtiming deviations, influencing their responses. Moreover, prior knowledge of the tracks could have shaped participants' preferences (Jakubowski & Francini, 2023). Notably, tracks 2 and 3 in Winquist's study failed to show significant results, likely due to these biases, as Winquist partially acknowledges. To mitigate these biases, our study carefully selected samples that were not overly popular, reducing the likelihood of familiarity or pre-existing preferences influencing responses. Additionally, we took note of whether participants had prior exposure to the given tracks.

Winquist's use of broad genre markers to select audio samples further limited the applicability of their findings, as cultural and contextual factors were not fully considered, making it difficult to generalise their conclusions to a specific genre. To address this limitation, our study focused specifically on hip-hop, allowing for a more in-depth exploration of groove within a single genre. While Winquist's study did not examine the influence of genre familiarity, we investigated differences between listeners and non-listeners of hip-hop to determine whether prior knowledge of the genre impacted groove perception. Furthermore, Winquist's comparative analysis, comparing only one quantised and one unquantised version of each track, without a standardised scale for measuring groove, limited the ability to assess the nuanced effects of quantisation. Participants could only express a preference for one version over the other, without specifying the degree of their preference. In contrast, our study evaluated varying degrees of quantisation, providing a more granular understanding of how rhythmic deviations influenced groove perception.

Danielsen et al. (2023) conducted a study exploring different musical parameters within the concept of microrhythm across five groove-based genres, including hip-hop. Data was collected through in-depth semi-structured interviews with 25 experts, each specialising in a specific genre. The interviews, lasting over an hour each, provided valuable qualitative insights into how rhythmic variations on the grid were perceived and employed by producers and musicians. The findings confirmed that in hip-hop, as in other groove-based genres, rhythmic quantisation significantly impacted how the music was received. Several hip-hop producers in the study expressed a strong preference for unquantised recording and sequencing, with some even manually adjusting quantisation between MIDI and audio, while others deliberately incorporated "flawed" playing to create a more natural groove. However, several producers still favoured a more stable, quantised rhythm.

While the study's findings are greatly relevant in highlighting the diversity of opinions on quantisation in hip-hop, there are limitations to consider, such as the demographic homogeneity of the sample. Although the study involved musicians from five different genres, all but a few participants were Norwegian. This raises concerns about the generalisability of the findings to other cultural contexts, as the musical influences and practices in Norway may not fully represent global trends in the genres studied.

Davies et al. (2012) conducted two experiments to examine the impact of microtiming variations on groove perception in three genres: Samba, Jazz, and Funk. The researchers used synthetic musical examples, ranging from fully quantised to those with "exaggerated microtiming," to maintain control over rhythmic manipulation. In Experiment 1, participants rated the samples based on two characteristics: "groove," and "naturalness," with participants rating these characteristics on a scale from 0 to 10. The results of Experiment 1 indicated that, overall, microtiming deviations reduced the perception of groove, with few exceptions. Experiment 2 explored whether non-musicians had difficulty appreciating subtle microtiming variations. Musicians, particularly those with performance experience, were able to recognise the synthetic nature of the samples and critiqued their "naturalness," while non-musicians did not. Non-musicians preferred the fully quantised samples, likely due to their lack of familiarity with microtiming variations. The key conclusion of Davies et al.'s study is that musical expertise significantly influences the perception of microtiming. Musicians, with their heightened sensitivity to rhythmic subtleties, are more accepting of rhythmic "inaccuracies," viewing them as a natural and integral aspect of the explored genres.

However, a limitation of the study is the use of synthetic examples, which as mentioned, compromised the validity of the findings. By asking participants to assess the 'naturalness' of synthetic samples, Davies et al. introduced an additional variable that influenced the musicians' assessments of groove. This undermines the ability to establish a clear causal relationship between microtiming variations and groove perception, limiting the generalisability of the study’s conclusions. In contrast, our study uses pre-existing tracks, offering a more authentic representation of hip-hop music. These real tracks align with the conventions and stylistic characteristics of hip-hop across its history, enhancing the legitimacy of the groove experience and providing a more accurate assessment of groove perception in the genre, contributing to the samples' perceived "naturalness”.

Nguyen et al. (2022) examined beat perception and production in musicians and dancers, exploring how factors such as expertise, training style, stimulus modality, and movement-type influenced these abilities. The study found that musicians tend to have more accurate rhythm processing and sensorimotor synchronisation performance compared to non-musicians. In Experiment 1, participants were tasked with judging whether a metronome was "on-beat" or "off-beat" when superimposed on various samples, while also tapping along to the beat of different musical genres (rock, jazz, and pop orchestral). Results showed that musicians outperformed dancers in both beat perception and production tasks, likely because the tasks were more auditory-focused, favouring musicians' training. Additionally, Nguyen et al. found no significant difference between percussionists and non-percussionists. However, this may be due to an inadequate distinction between the two groups, which calls into question the internal validity of the experiment, particularly regarding the classification of participants.

Experiment 2 incorporated audio-visual elements and more precisely distinguished between percussionists and non-percussionists. Results showed that dancers performed better in these tasks, suggesting that their training, which involves physical movement, made the task more ecologically valid for them. This finding highlights the importance of contextualised experience in beat perception and production. However, no significant difference was found between percussionists and non-percussionists in terms of beat production, emphasising that musical training, rather than percussion-specific experience, was the crucial factor for beat performance. Nguyen et al.'s study suggests that musical training plays the most significant role in shaping beat perception and production, while also highlighting that contextualised experiences, such as the physical movement involved in dance, can influence performance in audio-visual tasks.

Hypotheses. This study investigates how rhythmic quantisation influences groove perception specifically within hip-hop music. Hip-hop was selected because of its strong rhythmic emphasis, characteristic use of swing and microtiming, and its cultural association with groove-oriented production practices. Winquist’s (2024) findings, suggesting that quantisation often diminishes rather than enhances groove perception, form our hypothesis that small rhythmic deviations contribute to a sense of groove by introducing a “human” quality that strict quantisation lacks. Davies et al. (2012) found that the "grooviest" variation was not the fully quantised version, but rather one with slight rhythmic deviations. Based on this, we anticipate that a slightly less quantised sample may receive higher overall groove ratings than the perfectly quantised sample and anticipate that more extreme deviations beyond typical expressive timing will instead, reduce perceived groove across all listener groups.

Lastly, Nguyen et al. (2022) demonstrated that musical training plays a central role in shaping beat perception and production. Hence, we hypothesise that musical training will enhance groove perception in relation to rhythmic quantisation. Nguyen’s study also highlighted how prior training and experience influence musicians' interpretation of rhythmic patterns. We anticipate that musicians’ heightened sensitivity to subtle variations in rhythmic timing will lead to distinct responses to groove compared to non-musicians; the specific nature of these differences remains unclear. This gap in understanding is what our study seeks to address, by exploring how musical training shapes the perception of groove in the context of rhythmic quantisation.

2. METHODS

Design. A quantitative questionnaire design was used to examine how quantisation influenced groove perception. The primary independent variable was quantisation variance, while musical training and exposure to hip-hop were also explored as additional factors affecting perception. Given the nature of groove perception, numerical statistics provided a more efficient way to identify and analyse trends, compared to the large bodies of text typically generated in qualitative studies. The online questionnaire format also allowed for the collection of a relatively large dataset within a short period, especially under time constraints. Additionally, this approach enabled direct comparisons within and between different groups in our dataset and simplified data visualisation through graphs. Since our focus was to understand the 'what' and 'how' of groove perception rather than the 'why,' a qualitative approach was less suitable for our objectives, particularly as the 'why' had already been extensively explored in existing literature.

Participants. Thirty-five participants (21 male, 10 females, 1 non-binary, 1 unknown, mean age = 21.6 years) were recruited through social media and word-of-mouth using convenience sampling, with two excluded as outliers. Participants were evenly divided between musicians (17) and non-musicians (16), using the Gold-MSI to gauge musical sophistication. Additionally, participants' exposure to hip-hop music was measured, with 25 identifying as listeners and 8 as non-listeners.

Procedures. Participants completed the questionnaire through Qualtrics, rating the groove perception of each track on a Likert scale from 0 to 10, with higher scores indicating a more positive perception. Six hip-hop tracks were selected to avoid biases from prior exposure, and data from participants who had previously heard a track were excluded. Each track's drum loop was modified to create four variants (Table 1): fully quantised (Q), off-grid to a maximum of 1/96th of a beat (W), 1/64th of a beat (E), and 1/32nd of a beat (R). Each participant was presented with a randomly assigned variant from each track to prevent comparison bias.

Table 1

Quantisation variants

	Q	W	E	R
Maximum Microtiming Offset	Fully quantised (no offset)	1/96th of a beat	1/64th of a beat	1/32nd of a beat

Vocals were removed from each track using the AI-based stem-splitting tool: Fadr, ensuring participants focused solely on the instrumental and percussive elements, with each track consisting of an eight-bar loop (excluding pickups), in line with Winquist's (2024) study. To maintain consistent perceived loudness and minimise dynamic fluctuations, the same compressor was applied to all tracks, reducing volume bias (Blessing, 2007). A noise layer was also added to mitigate the effects of audio bleed. To create the quantisation variations, the extracted drum sample was imported into Logic Pro and split into individual drum hits. Random timing shifts were applied either forward or backward using a Gaussian random number generator (mean = 50, standard deviation = 17, range = 100). The generated number was then used to adjust each drum hit, with 0 indicating the hit moved furthest ahead of the beat and 100 indicating it moved furthest behind. For example, in the '1/32nd variant', a value of 0 corresponded to the hit being 1/32nd note ahead of the beat, while an output of 75 placed it 1/64th behind the beat. This method simulated drumming variations that reflected human error, as people tend to play closer to the beat than away from it, following a normal distribution.

3. RESULTS

Initial analysis indicated a polynomial relationship between groove ratings and quantisation variants (Fig. 1) [R^2 = 0.97 for polynomial vs. R^2 = 0.91 for linear]. However, closer examination revealed distinct differences between musicians and non-musicians, which contributed to this misleading overall trend. Non-musicians demonstrated a clear linear relationship between groove ratings and quantisation levels [R^2 = 0.96]. In contrast, musicians showed irregularities in their responses, disrupting the overall pattern and accounting for the deviations from linearity in the combined dataset (Fig 2a & 2b).

From the W variant onward, both groups exhibited a steady decline in groove ratings (Fig. 2a), with the R variant showing the lowest mean ratings, as anticipated. However, notable discrepancies emerged between the musicians and non-musicians. As shown in Fig. 2b, musicians demonstrated what we refer to as a "Q aversion"—a noticeably lower mean groove rating for the fully quantised Q variant—followed by a "W-spike", a sharp increase in ratings for the slightly unquantised W variant. Beyond this point, musicians maintained relatively stable ratings across the E and R variants, forming an "E–R plateau" that contrasts with the continuous decline observed among non-musicians. A two-sample *t*-test assuming unequal variances ($t(35) = –1.5$, $p = 0.14$) indicated that these discrepancies were not statistically significant, though the trend was consistent with the hypothesised differences between groups. The lack of significance likely reflects the limited sample size, suggesting that while the observed pattern aligns with theoretical expectations, the data was not sufficiently robust to confirm the effect statistically.

Figure 1

Quantisation variants against Mean 'groove' ratings: Error bars represent standard errors. Chance level is at 50%.

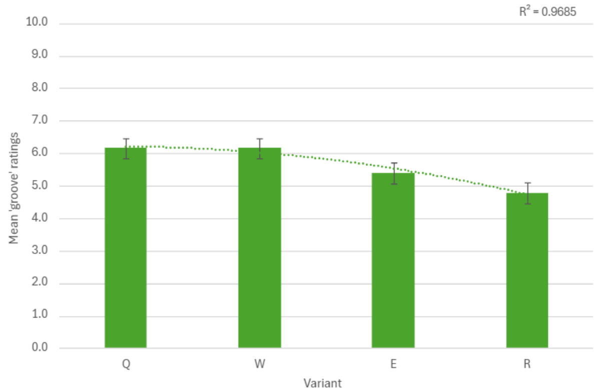


Figure 2a

Non-Musicians and Musicians against Mean 'groove' ratings: Error bars represent standard errors. Chance level is at 50%

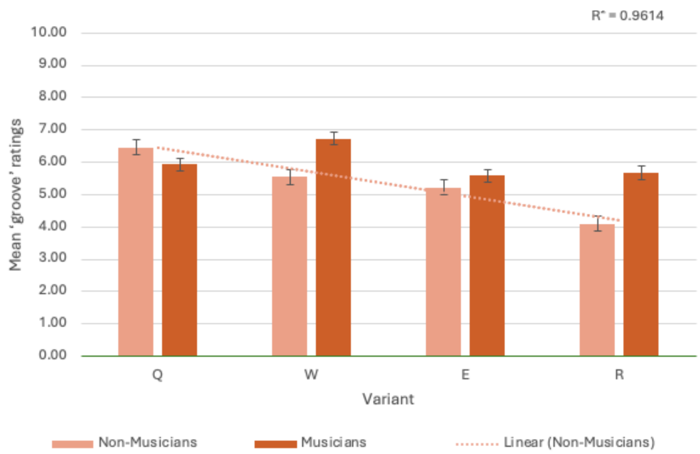


Figure 2b

Graphical annotations highlighting key discrepancies between musicians and non-musicians

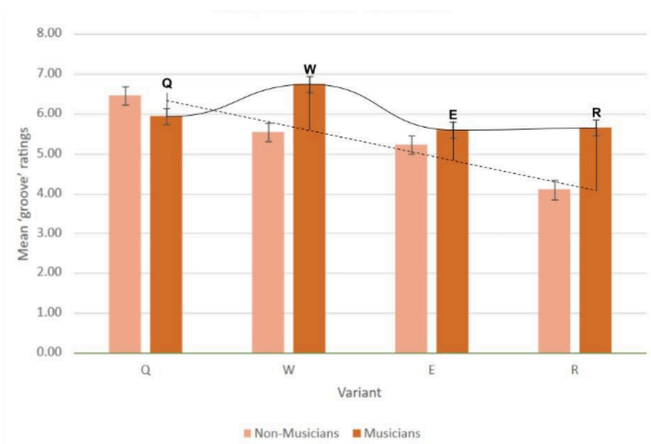


Figure 3

Male and Female against mean 'groove' ratings: Error bars represent standard errors. Chance level is at 50%.

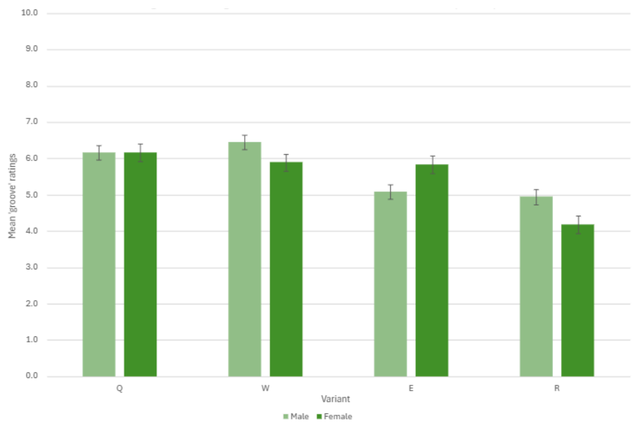
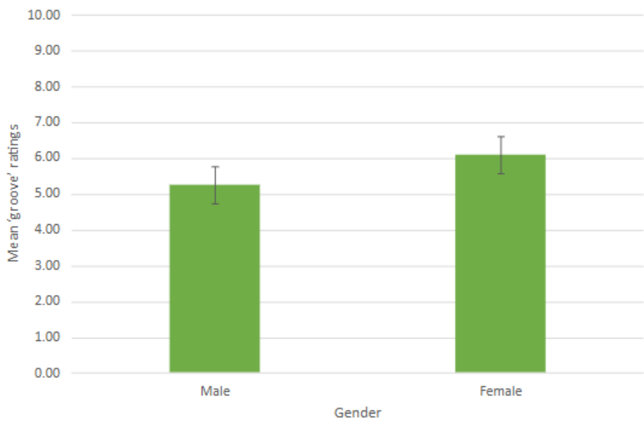


Figure 4

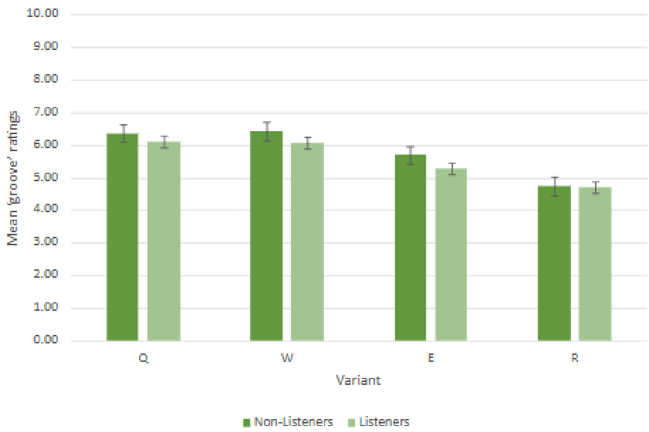
Male and Female (non-Musicians) against mean 'groove' ratings: Error bars represent standard errors. Chance level is at 50%



Further analysis involving the gender variable (Fig. 3) revealed a notable pattern: male participants rated the W variant higher than the Q variant, consistent with the earlier observed W-spike. Conversely, this spike was not observed in female participants' ratings, suggesting the involvement of an additional factor contributing to the W spike. To isolate the influence of gender on the W spike, we excluded musician participants from the data pool, resulting in Fig. 4. A t-test conducted on this subset indicated no significant difference between male and female ratings, suggesting that the W spike was addressed in the non-musician dataset [$t(33) = 0.28$, $p < 0.78$]. However, the *p*-value from this analysis was insufficiently robust due to the exclusion of musician data, limiting the conclusiveness of this result. Based on these findings and the comparative analysis in Fig. 2a & 2b of musician and non-musician responses, we conclude that the W spike is primarily driven by musical experience.

Figure 5

Non-Listeners and Listeners against mean 'groove' ratings: Error bars represent standard errors. Chance level is at 50%



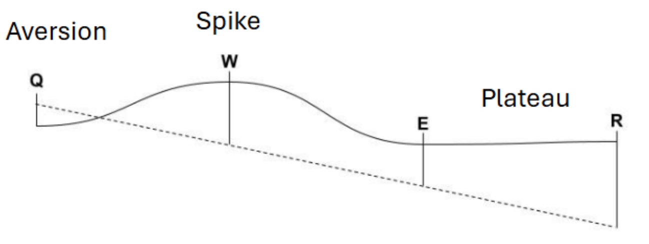
In Figure 5, the W-spike also appeared among non-hip-hop listeners, a finding likely shaped by the influence of musical experience. Without this confounding factor, the presence of the W-spike in this group would be unexpected, given their limited familiarity with hip-hop conventions.

4. DISCUSSION

Non-musician participants demonstrated a clear linear relationship between groove ratings and quantisation variance, in contrast to the polynomial trend observed in the overall dataset (Fig. 1). This suggests that non-musicians assess groove in a relatively direct perceptual manner, responding proportionally to the degree of rhythmic regularity, implying that deviations from the beat are primarily experienced as instability rather than expressive nuance. Conversely, musicians exhibited a pronounced W spike, indicating a strong preference for slightly off-beat variants (see Fig. 6). Additionally, musicians gave higher ratings for the E and, particularly, the R variants, suggesting a greater tolerance for less quantised rhythms. This finding supports the tolerance hypothesis, indicating that individuals with musical experience are more accepting of timing deviations in rhythm and may even perceive these variations as enhancing groove.

Figure 6

Theoretical model illustrating the factors contributing to groove perception discrepancies observed in musicians



At the Q variant, musicians displayed an unexpected aversion to the perfectly quantised rhythm, which may be attributed to their extensive exposure to human performances, which are inherently imperfect. This aligns with Nguyen's (2022) findings that musical training increases tolerance to rhythmic variation and deviation. However, Nguyen's study does not address the possibility that musicians might lose interest in perfectly quantised rhythms, a phenomenon that our research has identified. Furthermore, the relationship between the E and R variants provides additional evidence of this tolerance. While non-musicians showed a consistent decline in groove ratings from E to R, musicians exhibited an E-R plateau, suggesting that they perceive little difference in groove quality between these two highly unquantised variants. This pattern further reinforces the idea that musicians possess both a higher threshold and greater sensitivity to rhythmic deviation, their perceptual acuity allowing them to distinguish expressive microtiming variations from genuine rhythmic instability and to appreciate the more pronounced timing deviations of the R variant without a corresponding decline in perceived groove.

In the context of our findings, the W-spike observed among musicians aligns with some of the concepts discussed in Butterfield (2010) and Winquist's (2024) research on microtiming deviations. Winquist notes that positive associations with groove were found in microtiming conditions of around 40ms and 20ms for jazz samples, which are close to the 30ms threshold Butterfield (2010) suggests, beyond which microtiming deviations become harder to detect. As Winquist cautions, the exact threshold at which timing deviations become either beneficial or detrimental to groove perception has yet to be well defined. This remains a critical consideration in understanding the W-spike, as the fine line between perceptible, intentional deviations and those that are too extreme may vary across individuals, depending on factors such as their exposure to and familiarity with different types of music, as well as musical expertise. Thus, the W-spike observed in musicians may reflect a well-tuned sensitivity to timing variations that are just enough to feel intentional and groovy, without crossing into imperceptible or overly extreme territory where rhythmic variations lose their musicality or groove-enhancing qualities. Additionally, the existence of the W-spike reinforces the idea that there is a "sweet spot" for groove in quantisation among musicians. This suggests that musicians are not simply more tolerant of rhythmic deviations but actively prefer a certain level of variation in timing to maximise their perception of groove.

Both hip-hop and non-hip-hop listener groups exhibited similar linear trends in groove ratings, with groove perception decreasing proportionally as quantisation deviations increased. This suggests a shared framework for evaluating rhythmic regularity, regardless of stylistic background. However, non-hip-hop listeners provided higher overall groove ratings than hip-hop listeners, possibly reflecting the latter group's tendency to critically scrutinise groove (or the perceived ”authenticity” of the samples) due to their greater familiarity with the genre. Despite this difference, both groups agreed that the R variant was too off-beat to maintain a sense of groove, indicating a universal threshold for timing deviation beyond which groove perception diminishes. Finally, no significant differences were found between male and female participants in their groove ratings, suggesting that gender did not influence groove perception in this study.

Limitations. Winquist’s study touches on intentionality in rhythm, which is highly relevant to our research as well. While we use a Gaussian distribution to simulate intentionality in rhythmic deviations, this method has its limitations. In real-life performances, musicians often exhibit a natural tendency to correct early or late notes, creating a horizontal correlation between note placements (i.e., if one note is early, subsequent notes are likely to be early as well). Our approach, however, does not simulate this corrective behaviour, which may fail to fully capture the nuances of real-world performance. This could influence the groove perception ratings, as participants may not perceive the variations as intentional or humanised. Additionally, our tracks focus primarily on percussive elements, which may not fully capture the complexity of musical interaction found in more densely textured instrumental compositions. A more realistic simulation, with interactions between various instruments, might lead to higher groove ratings, as the perceived intentionality in a full ensemble context could be more compelling for listeners. Keil’s theory of Participatory Discrepancy (1995) offers a relevant perspective here, as it suggests that slight variations in timing and tone are not merely mechanical errors but rather foster a deeper sense of engagement and communal participation. These discrepancies enable dynamic responses between musicians, contributing to the groove. In our study, samples that are percussion-heavy with less harmonic texture make the lack of realistic instrumental interaction less apparent. However, in tracks where the instrumental texture is thicker, it becomes more evident that the percussion is not interacting with the other musical elements in a truly human way. This discrepancy could expose the limitations of our method of simulating intentionality, which in turn may reduce the perceived groove, as it lacks the sense of dynamic interplay that Keil (1995) describes.

Another limitation concerns the statistical robustness of our findings. While trends such as the “Q aversion,” “W-spike,” and “E–R plateau” were consistent with our hypotheses, the corresponding t-tests did not reach statistical significance ($t(35) = -1.5$, $p = 0.14$). This suggests that the observed effects may reflect genuine perceptual tendencies but could not be confirmed with confidence due to the limited sample size. A larger participant pool would help clarify whether these differences represent reliable group effects or artefacts of sample variability. Additionally, the participant pool for this study was relatively small, limiting the generalisability of some of the findings. A larger and more diverse sample would have allowed for more definitive conclusions, especially regarding gender correlations. Lastly, a limitation lies in the subjectivity of ‘groove’. Participants likely had different interpretations of what constitutes groove, which may have affected their ratings. Future studies could address this by either providing a clear definition of ‘groove’ for participants or, if time permits, collecting qualitative data on how participants define it, as Winquist (2024) did. The imbalance in our gender and musicianship groups is another factor that may have influenced our results, particularly in relation to the W-spike preference.

Advancements and Future Directions. Despite these limitations, this study contributes to the field by advancing research on rhythmic variation, particularly in hip-hop, a genre previously underexplored in this context. Our research adds depth to existing literature by introducing a wider range of quantisation levels and comparing responses based on musical background, such as musicians versus non-musicians, and familiarity with hip-hop. This work builds on previous studies, but future research would benefit from a larger sample size to further enhance data validity and confirm these trends. Furthermore, balancing gender and musicianship among participants would help eliminate biases and improve the robustness of the findings.

One area for further research is the cross-cultural examination of groove perception. Different cultures may perceive tempo, meter, and micro-rhythms differently, and exploring how participants from various cultural backgrounds react to rhythmic deviations could provide a more global perspective on groove perception. Future studies could also expand the definition of ‘groove’ to include physiological aspects, such as the desire to move, dance, or tap along to music. This has been explored in other genres, such as jazz, by Davies et al. and Nguyen et al., but has yet to be applied to hip-hop specifically. Additionally, researchers could explore the concept of ‘naturalness’ and its connection to intentionality and human error, as discussed by Keil (1995), as well as the balance between quantisation and humanisation, which may influence groove perception. Understanding the factors that contribute to the ‘sweet-spot’ in groove—where rhythmic deviations are most effective—could provide further insight into how small timing variations enhance musical enjoyment.

Lastly, while this study focused on rhythmic quantisation and microtiming, future research should explore other musical features that contribute to groove perception. For example, Madison et al. (2006) identified event density and fast metrical levels as key components of groove, and examining how these factors interact with rhythmic variation could offer additional insights into what makes music feel groovy. Further investigation into why participants, especially musicians, prefer the W variant could also shed light on the thresholds of rhythmic variation that enhance groove without detracting from its musicality.

5. CONCLUSION

This study explored how rhythmic quantisation affects groove perception in hip-hop music, examining the role of musical training, exposure to hip-hop, and quantisation variance in shaping groove ratings. Our results indicate that musicians are more tolerant of and sensitive to timing variations, exhibiting a preference for slightly off-beat rhythmic deviations, reflecting their ability to appreciate microtiming nuances. The observed W-spike among musicians supports the notion of a “sweet spot” for groove, where moderate timing variations enhance the perception of intentionality and groove without becoming imperceptible or overly extreme. In contrast, non-musicians showed a stronger preference for fully quantised rhythms , highlighting their lesser tolerance for rhythmic deviations.

Interestingly, we found that musicians exhibited an E-R plateau, where they perceived little difference in groove quality between two highly unquantized variants (E and R). This plateau suggests that musicians' tolerance for rhythmic deviations reaches a point where further variations do not significantly enhance their groove perception, supporting the tolerance hypothesis. Moreover, the aversion to perfectly quantised rhythms (Q aversion) observed in musicians is a novel finding that builds on previous literature. While prior studies have discussed musicians' tolerance for rhythmic variations, our study uniquely identifies that musicians actively prefer a certain level of timing flexibility over perfectly quantised rhythms, suggesting that a rigid, mechanically precise rhythm may detract from the perceived groove. Additionally, hip-hop listeners exhibited more discernment in their groove ratings, with a more critical approach to rhythmic variations compared to non-hip-hop listeners. This heightened sensitivity could reflect their deeper familiarity and engagement with the genre’s rhythmic complexity. Both hip-hop and non-hip-hop listeners shared a common threshold for what constitutes a groove, agreeing that the R variant, which deviated too far from the beat, detracted from the overall groove. No significant differences were found between male and female participants, suggesting that gender did not influence groove perception in this study.

Overall, this research contributes to the understanding of how rhythmic deviations influence groove perception and underscores the importance of both musical training and genre familiarity. The findings suggest that musicians’ enhanced sensitivity to microtiming deviations fosters a more dynamic and engaging groove experience, while non-musicians' preference for quantised rhythms reflects a more rigid approach to rhythmic timing. This study lays the groundwork for future research on groove perception in hip-hop and other genres, particularly in relation to musical training and the role of intentionality in rhythm.

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