MEASURING RHYTHMIC COMPLEXITY IN KOREAN JANGGU JANGDAN: A SYNCOPATION-BASED APPROACH

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ABSTRACT

Syncopation has been established as an objective measures of rhythmic complexity in Western popular music, yet its applicability to non-Western traditions remains underexplored. This study adapted existing syncopation indices for Korean traditional *janggu jangdan* by decomposing them into monophonic components for each instrument layer—*gung* and *chae*—and by developing a syncopation index that accounts for polyphonic interactions. Ninety-four participants rated the perceived rhythmic complexity of 40 *jangdan* patterns and 50 Western drum patterns. Correlational analysis showed that monophonic *chae* syncopation and polyphonic syncopation with optimized instrumental weights outperformed existing drum syncopation indices in predicting perceived complexity. This study introduces the first computational method for Korean *jangdan*'s rhythmic complexity, proving that syncopation metrics can extend to non-Western traditions through culture-specific adaptation.

1. INTRODUCTION

Groove has been linked to rhythmic complexity through an inverted U-shaped relationship [1–5], with complexity measured primarily through syncopation—the placement of note onsets at metrically weak positions followed by rests at stronger positions [6]. However, this framework has been largely confined to Western drum patterns in 4/4 meter. Previous studies showed that groove peaks at low complexity in uncommon meters [7], and metric frameworks vary substantially across cultures [8, 9], suggesting that rhythmic complexity may function differently in non-Western traditions.

Jangdan are the rhythmic patterns foundational to Korean traditional music, performed primarily on the *janggu*—a double-headed drum whose left (*gung*) and right (*chae*) heads serve distinct rhythmic functions. Most *jangdan* operate within ternary-based asymmetric metric cycles (e.g., 12/8) that differ fundamentally from Western meters, yet no prior study has quantified their rhythmic complexity. The present study addresses this gap by adapting syncopation-based complexity measures for *janggu jangdan* and validating them against listeners' perceived complexity ratings.

2. MATERIALS AND METHODS

2.1 Participants

Ninety-four adults participated in the study (52 non-musicians, 33 Korean traditional music majors, 4 classical music majors, 5 popular music majors; mean age = 28.93, SD = 7.70). All participants provided written informed consent prior to participation.

2.2 Stimuli and Procedure

Forty jangdan patterns in 12/8 meter were synthesized using MIDI with a janggu virtual instrument with quantized velocity and timing. The set comprised 28 patterns drawn from actual performance practice and 12 artificially constructed patterns designed to broaden the distribution of rhythmic complexity. For comparison, 50 Western drum patterns from Witek et al. [1] were synthesized. All stimuli were at 80 bpm and RMS levels were controlled for both stimulus sets.

The experiment was conducted online. Each participant was randomly assigned to one of three counterbalanced sub-sessions, rating perceived rhythmic complexity on a 0-100 continuous slider scale (mean responses per stimulus ≈ 31.3).

2.3 Rhythmic Complexity Measures

Monophonic syncopation was computed separately for the *gung* and *chae* layers following [1]. Each layer's rhythmic pattern was represented as a binary onset sequence over a 24-slot grid, with metric weights assigned hierarchically to each position (Figure 1). Syncopation occurs when a note onset (syncopator) is followed by a rest, and the first resting position before the next onset carries a higher metric weight than the syncopator—that position is designated the syncope. The metric difference (*md*) was defined as $md = w(\text{syncope}) - w(\text{syncopator})$, and the monophonic syncopation index was the sum of metric differences of all syncopation events.

Building on Hoesl and Senn's work [10], a polyphonic syncopation was computed by classifying each syncopation event according to the onset states of both layers at the syncope position: *gung*-only, *chae*-only, or two-stream (both layers absent at the syncope). The syncopation value (*sv*) for each event was defined as $sv = md + iw$, where iw is an instrumental weight assigned to each event of syncopation. The polyphonic syncopation was the sum of syn-

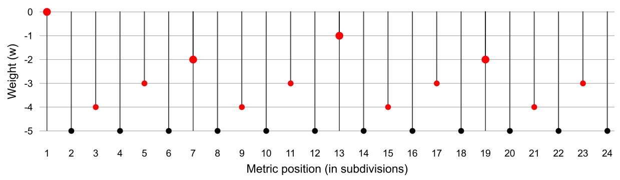

Figure 1. Weight (w) per metric position for janggu jangdan. Red markers denote the eighth-note positions, while black markers represent the intermediate sixteen-note subdivisions.

copation values of all syncopation events. To identify instrumental weights appropriate for *janggu*, all integer combinations in $\{0–5\}^3$ (216 combinations) were exhaustively evaluated based on their correlation with perceived complexity ratings.

As baseline measures, *Number of Note Onsets* [11], *Pulse Entropy* [7, 12], and *Pulse Clarity* [13] were also computed.

3. RESULTS

Table 1 and Figure 2 presents Pearson correlations between each measure and perceived complexity ratings for the 40 *jangdan* stimuli. Among the monophonic components, *chae* syncopation yielded a strong significant correlation ($r = .828$, $p < .001$), whereas *gung* syncopation was not significant ($r = .164$, $p = .312$). Both *Number of Note Onsets* and *Pulse Entropy* were significant but showed weaker correlations than the syncopation-based measures. Pulse Clarity was not significant.

Measure	r	$t(38)$	p	R^2
Monophonic Gung	.164	1.026	.312	.027
Monophonic Chae	.828	9.101	< .001	.686
Polyphonic	.862	10.48	< .001	.743
Number of Note Onsets	.770	7.445	< .001	.593
Pulse Entropy	.724	6.471	< .001	.524
Pulse Clarity	-.199	-1.251	.219	.040

Table 1. Pearson correlations of six measures of rhythm complexity with Perceived Complexity ($N = 40$). Polyphonic was computed with instrumental weights IW = (0, 0, 1) for gung-only, chae-only, and two-stream events.

The exhaustive grid search revealed that the top 16 instrumental weight configurations exceeded the correlation of monophonic *chae* syncopation. The optimal configuration for gung-only, chae-only, and two-stream events was IW = (0, 0, 1) (Table 1).

For comparison, Witek et al.'s [1] syncopation index applied to Western drum stimuli yielded $r = .566$ ($p < .001$, $R^2 = .320$), indicating that the *jangdan*-specific measures achieve substantially higher predictive validity for their target domain.

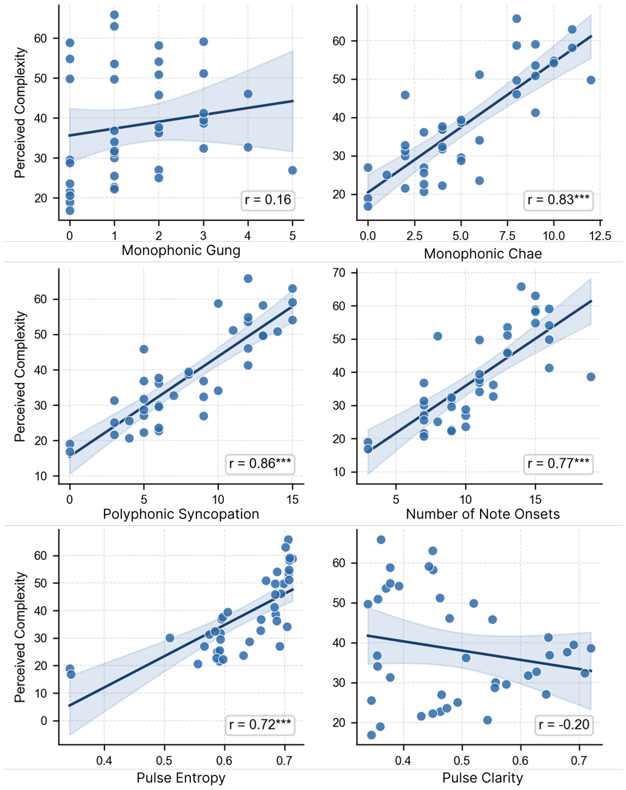

Figure 2. Scatter plots of perceived complexity against six rhythmic complexity measures. Shaded regions indicate 95% confidence intervals.

4. DISCUSSION AND CONCLUSIONS

The strong correlation of monophonic *chae* syncopation with perceived complexity, relative to the non-significant effect of *gung* syncopation, indicates that the *chae* layer is the primary driver of rhythmic complexity in *janggu jangdan*. This finding aligns with the acoustic and functional characteristics of the instrument. Acoustically, the chae-side produces a higher-pitched, sharper attack than the low-frequency gung-side, providing greater perceptual salience that draws the listener's attention. From a performance practice perspective, the gung-side often serves as a metric anchor, typically falling on the strong beats of the cycle to provide structural stability. In contrast, the chae-side is frequently utilized for decorative strokes and ornamental variations that often occur on metrically weak positions or subdivisions.

Critically, both rhythmic complexity measures—monophonic *chae* and optimal polyphonic syncopations—outperformed not only baseline measures (*Number of Note Onsets*, *Pulse Entropy*, and *Pulse Clarity*) but also the syncopation index on Western drum stimuli. These results validate the *jangdan*-specific complexity measures as empirically superior.

To our knowledge, this is the first study to quantify the rhythmic complexity of Korean traditional *jangdan* through a systematic and empirically validated approach. This study opens a path toward a broader, cross-culturally informed theory of rhythmic complexity and groove.

5. ACKNOWLEDGMENTS

Acknowledgments will be included in the final manuscript after the review.

6. AI USAGE STATEMENT

AI tools were used to assist in data analysis and visualization. In addition, the tool was used to improve the manuscript to improve clarity and readability. After using AI tools, the first author reviewed and edited the content as needed and takes full responsibility for the final content of the publication.

7. ETHICS STATEMENT

The ethics statement will be included in the final manuscript after the review.

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