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# Percussive rhythm with claves in rumba—A measurement

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## 1. Introduction

This article presents a measurement of percussive rhythm played with claves, a hand-held percussion instrument, in a performance of El Manicero. El Manicero (The Peanut Vendor) is a Latin-American music whose music style is called rumba (in the sense of "son"). The finding is that the overall performance speed is kept quite metronomic, in which the realized percussive rhythm is maintained strictly in a way deviated slightly from that of the notated one.

This music, composed by Moises Simon and performed in 1930 by Don Azpiazu and his Havana Casino Orchestra, was known as the boom-maker of rumba music prevailing over the world in the 1930s. The sound material for the present study is taken from the orchestra's debut recording made in May, 1930. It has a special significance in that not only it became a million seller but also it is regarded as a historical recording that initiated a worldwide acceptance of rumba music thereafter.

Here we cite a story of calling the style of this music "rumba."[1] In the traditional sense, this music was "son" which designates a style of Afro-Cuban music originated in Oriente Province, whereas rumba had been the style of another Afro-Cuban music that was for urban folklore in Havana and Matanzas. Confusion came out when the music publisher in the United States published the score of this music as "rhumba" in its revised edition by changing from the original son to avoid mistake for song. Also interesting is that the label of the original SP record had an imprint of "rumba fox trot." In this paper, we assume that the rumba designates the music style of El Manicero and others that won a commercial success in the 1930s, *i.e.*, rumba in the sense of son.

## 2. Measurement

The sound material for measurement is a restoration in CD[2] from the above mentioned SP record (Victor 22483-A). The analog output from CD player was recorded via DAT at the sampling rate of 48 kHz, then the sampled DAT signal was processed digitally by the running FFT method with 1,024 points under a Hanning window and running step of 5 ms.

Before making a measurement of the performance, we studied the sound of solo claves with the same FFT method. This musical instrument is a pair of solid, hardwood cylindrical blocks, each about 20 to 25 cm in length and 2.5 to 3 cm in diameter. When struck together, they make a very sharp, high-pitched, and fast-decaying percussive sound. Figure 1 shows a typical temporal profile of the sound in terms of acoustic energy and its spectral components. The energy envelope appears pulsive and the frequency of the dominant vibration mode lies around F♯7. Because of these two acoustic characteristics together, the onsets of this instrumental sound can be identified rather easy in a dense sound signal of ensemble music which is a mixture of many instrumental sounds. The ambiguity in the identified times of onsets is estimated within 2 running steps or 10 ms at worse owing to the sharp attack. This ambiguity arises from the window width of the FFT analysis.

Figure 2 shows a generic rhythmic pattern played with claves in rumba $C_{3\text{-}2}$, and its alternate, $C_{2\text{-}3}$, where the three note pattern consisting of two dotted eighth notes followed by an eighth one is called the *Cuban tresillo*. Which of $C_{3\text{-}2}$ and $C_{2\text{-}3}$ takes place depends

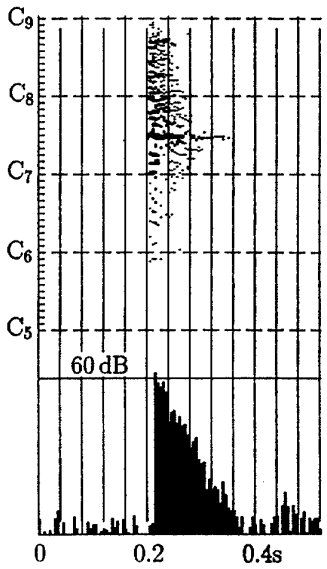


**Fig. 1** Acoustic characteristics of the solo claves sound: development of energy (lower), and spectral components (upper).

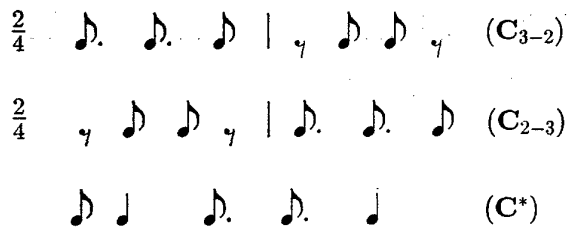


**Fig. 2** Claves rhythms in rumba. Generic rhythm $C_{3\text{-}2}$ and its alternate $C_{2\text{-}3}$, together with a note pattern C* for purpose of data analysis.

**Table 1** Sequence of *IOI*'s of the claves sound (unit in ms).

| | $j=1$ | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $i=1$ | 340 | 665 | 535 | 475 | 680 |
| 2 | 350 | 670 | 525 | 480 | 665 |
| 3 | 365 | 660 | 530 | 455 | 695 |
| 4 | 360 | 650 | 520 | 475 | 670 |
| 5 | 360 | 645 | 525 | 450 | 655 |
| 6 | 365 | 665 | 505 | 480 | 685 |
| 7 | 350 | 680 | 530 | 495 | 655 |
| 8 | 375 | 650 | 525 | 490 | 675 |
| 9 | 360 | 655 | 515 | 495 | 685 |
| 10 | 360 | 660 | 510 | 480 | 675 |
| | | (60 rows omitted) | | | |
| 71 | 365 | 685 | 505 | 520 | 660 |
| 72 | 365 | 680 | 520 | 495 | 680 |
| 73 | 370 | 665 | 530 | 485 | 670 |
| 74 | 380 | 675 | 530 | 505 | 665 |

on particular music, and it is $C_{2\text{-}3}$ in El Manicero. For the study on the performed rhythm, however, we use a schematic note sequence C* as a substitution for $C_{2\text{-}3}$. Here, C* is the pattern derived from $C_{2\text{-}3}$ by moving the leading eighth rest to the tail, then replacing two occurrences of the resulting eighth note – eighth rest combination with quarters notes. The reason for use of C* is that we cannot identify the onset times of rests. We shall call C* the rhythmic unit for convention. Let $\rho_j$'s ($j=1, \cdots, 5$) denote the five note values of C*, *i.e.*, $\rho_1=1$, $\rho_2=2$, $\rho_3=1.5$, $\rho_4=1.5$, and $\rho_5=2$, each represented in the unit of eighth notes.

The music lasts for about 3 min 30 s, and the claves continue to take part in the ensemble except in a few opening and ending bars. Table 1 presents the measured inter-onset intervals (*IOI*'s) which are in multiples of 5 ms, each row consisting of five successive *IOI*'s that correspond to $\rho_j$'s ($j=1, \cdots, 5$).

## 3. Data analysis

Let $d_{ij}$ denote the values of *IOI* in Table 1 where the subscripts $i$ and $j$, respectively, designate the row number ($1 \leq i \leq 74$), and the column number ($1 \leq j \leq 5$).

**Table 2** Statistical result of timing measurement.

1. Rhythmic unit C*
   Mean duration $\bar{D}=2{,}714.1$ ms
   Standard deviation $S=21.4$ ms.
2. Five *IOI*'s in C*

| $j$ | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $\rho_j$ | 1.000 | 2.000 | 1.500 | 1.500 | 2.000 |
| $\bar{r}_j$ | 1.054 | 1.989 | 1.523 | 1.449 | 1.985 |
| $s_j$ | 0.031 | 0.037 | 0.037 | 0.033 | 0.039 |
| $z_j$ | 14.937 | −2.621 | 5.364 | −13.229 | −3.354 |

i) $\rho_j$ is the notated value of $j$-th *IOI*.
ii) $\bar{r}_j$, $s_j$, and $z_j$, respectively, are the mean, standard deviation, and $Z$ statistic of the $j$-th *IOI*.

We are going to decompose this timing pattern into the performed duration over the rhythmic unit C* and a set of the relative durations of those within it. For this purpose, put $D_i=\sum_{j=1}^{5} d_{ij}$, and put $r_{ij}=8\times d_{ij}/D_i$. The $D_i$ gives the duration of $i$-th unit $C_i^*$, and the $r_{ij}$ give the relative durations within $C_i^*$. Here, the multiplier 8 in the definition of $r_{ij}$ is chosen so that $r_{ij}$'s in $C_i^*$ constitute total 8 counts which equal the duration of C* in the unit of eighth notes. For example, the values in row 1 (*i.e.*, $C_1^*$) are converted to $D_1=2{,}695$ ms; $r_{11}=1.009$, $r_{12}=1.974$, $r_{13}=1.588$, $r_{14}=1.410$, and $r_{15}=2.019$ where $\sum_{j=1}^{5} r_{1j}=8$.

Rewrite Table 1 in terms of $D_i$'s and $r_{ij}$'s. Then, compute the sample mean, $\bar{D}$, of 74 $D_i$'s with the sample standard deviation, $S$; similarly, compute for each $j$ ($j=1, \cdots, 5$) the sample mean, $\bar{r}_j$, of 74 $r_{ij}$'s with the sample standard deviation, $s_j$'s. Table 2 summarizes the result. The table contains also the values of $Z$ statistic defined by $z_j=(\bar{r}_j-\rho_j)/(s_j/\sqrt{n})$, where $n=74$.

From Table 2, we find the following. First, the rhythmic unit has a mean duration $\bar{D}=2{,}714.1$ ms with standard deviation $S=21.4$ ms. This means that the relative temporal fluctuation in the durations of rhythmic unit is 0.0079 (or 0.79%) in terms of $S/\bar{D}$, being performed at a mean metronomic speed of 88.4 beats/minute. Second, the five *IOI*'s in the rhythmic unit deviate consistently from the correspoinding $\rho_j$'s such that the first and third ones are lengthened, and the second, fourth, and fifth ones are shortened. Among these, the first one is lengthened by 5.4%, and the fourth one is shortened by 5.1% in the unit of eighth notes, respectively; and specifically, the two dotted eighth notes in the Cuban tresillo are played such that $\bar{r}_3:\bar{r}_4=1.523:1.449=1.051:1$. Each of these five deviations is significant statistically as the associated $Z$ statistic indicates. In fact, even in the least significant case $j=2$, *i.e.*, $z_2=-2.621$, the null hypothesis

$$H_0: \bar{r}_2=\rho_2 \quad (\rho_2=2.0)$$

is rejected at a significance level $\alpha=0.0088$ (0.88%) by

the two-tailed $Z$ test. In the cases of $j=1$ and $j=4$, the deviations are statistically much more certain because of their very large absolute values of $Z$ statistic.

## 4. Conclusion

It is said that in Latin-American dance rhythms, particularly the rumba, the steady and unchangeable beat of the claves constitutes a relentless ostinato.[3] The present study revealed the physical timing of this ostinato in two aspects: the overall tempo of the entire music, as measured with the claves sound, is kept metronomic very accurately, and the five *IOI*'s of C* are maintained strictly to be in their own temporal proportions which are deviated by 5.4% at maximum from the notated ones.

## References

1) T. Nakamura, "Explanation of music," in *A Guide to the Cuban Music* (*AB05*) (Audi-Book Co., Tokyo, 1990) (in Japanese).
2) Music No. 8 in the attached CD of AB05 (Ref. 1) above).
3) Item "Claves," in *The New Grove Dictionary of Music and Musicians*, Vol. 4 (MacMillan & Co., London, 1980), p. 457.