In Situ Acoustic Analysis of Two 20th-Century Heritage Carillons

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Research article

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Abstract

Carillons are a diverse and global form of musical and civic heritage: musical instruments comprised of a series of 23 or more bells, typically hung in a tower-like structure, tuned chromatically and played from a touch-sensitive manual and pedal console using an elaborate mechanical action. Carillon bells have a distinct series of musical overtones which need to be accurately tuned to one another and with other bells they sound alongside. Although these overtones have been previously studied ex situ, this study assesses the acoustic characteristics of two early-20th century carillons in Toronto, Canada as a combination of structure, bells, and mechanical action. Thus, the instrument and its context are considered holistically, more accurately reflecting the musical sensitivity of a carillonist. Spectral and Fourier analysis of audio samples of each bell at different musical dynamic levels enabled the analysis of the acoustic qualities of the bells and the mechanical action of the instruments. The tuning of bells in the instruments varied; most importantly, there was a significant difference between the audial intensity of the bell tones produced by the instruments, demonstrating the importance of the mechanical action as part of the 'carillon system'. This was represented with a resistive power-law model, that represents the sensitivity of intensity to carillonist musical dynamic level. A discussion of the implications for artistic and heritage practice follows. Understanding the in situ physical acoustics of the carillon as a holistic instrument in its context informs performers, arrangers, and composers of how they can best embrace the instrument's unique qualities to improve artistic pursuits and support the appreciation of carillons as heritage instruments and function as civic voices.

Full Text

This preprint is available for download as a PDF.

Figures

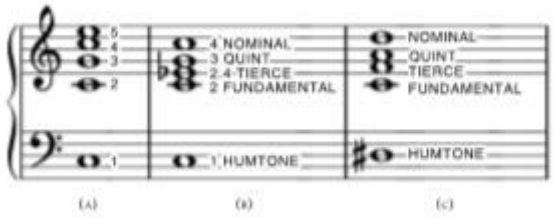

Figure 1

Comparison of overtone series. The tuned carillon bell would be notated by the fundamental tone, C4. (A), the natural harmonic series, (B), a tuned carillon bell, (C), an untuned bell

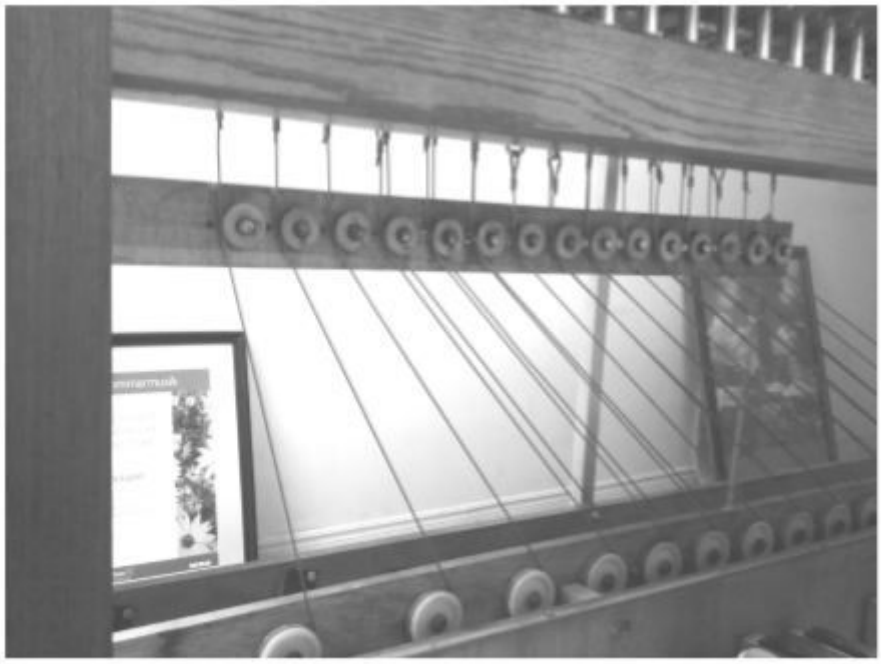

Figure 2

The pedal board of the carillon at the Metropolitan United Church, which has an irregular connection of guiding roller wheels to connect the pedals to the keyboard batons.

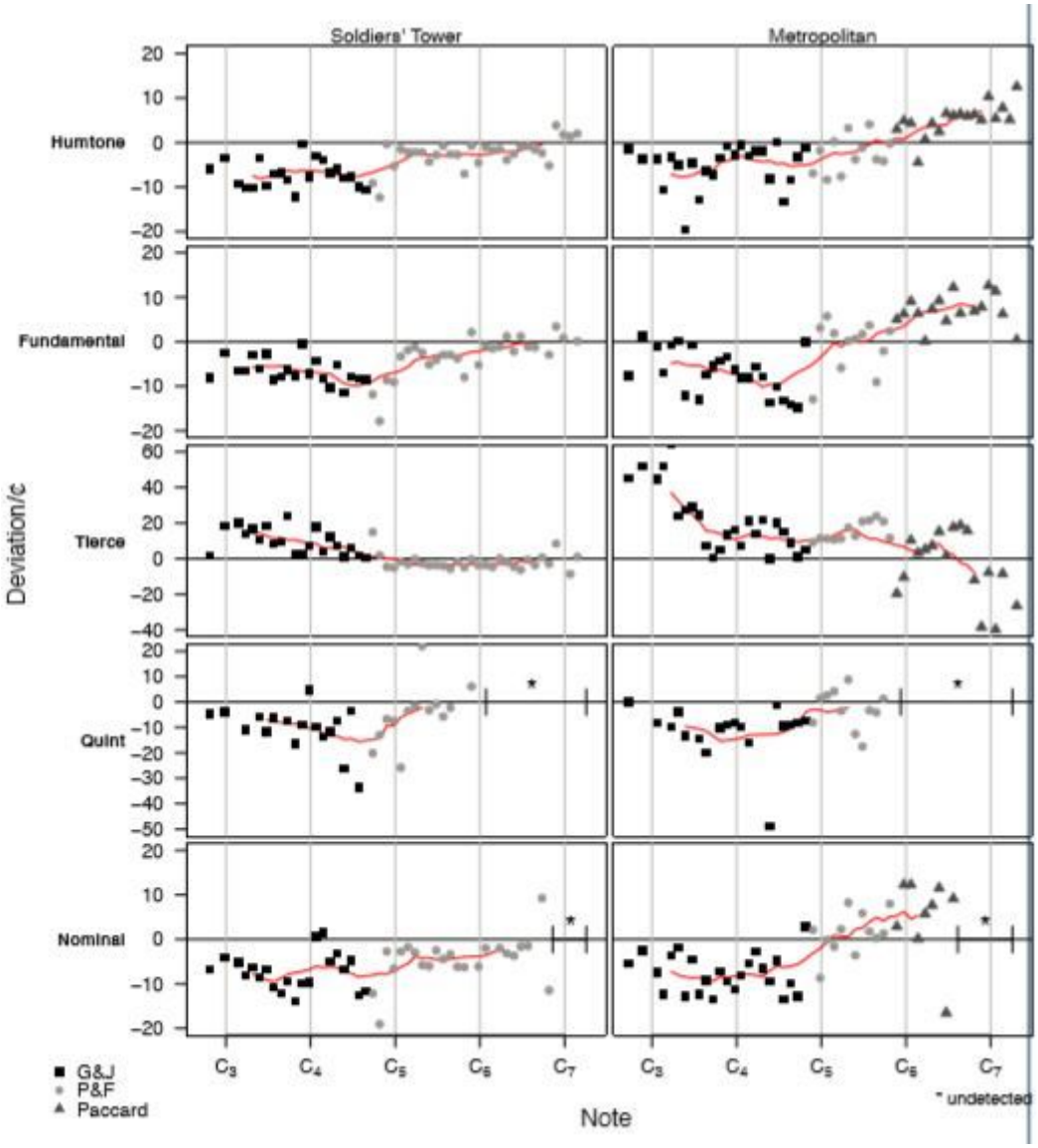

Figure 3

Frequency deviations for the five primary overtones in the Metropolitan and Soldiers' Tower instruments. The deviations are expressed relative to the frequencies that the bells were reportedly tuned to at time of production. It is noteworthy that in both sets of bells the quint and the nominal were not detected for roughly the highest half and full octave of bells, respectively. The red line indicates a moving average (n = 10), indicating the general trend with increasing bell frequency.

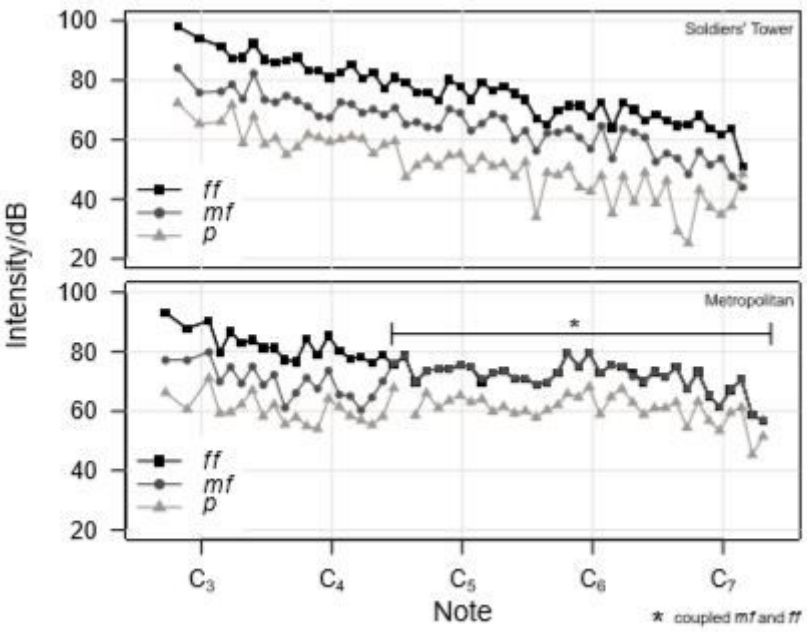

Figure 4

Bells of the Metropolitan and Soldiers' Tower instruments in which warble was detected. Warble was assessed by visual inspection of intensity spectra for individual bells. The carillon of Soldiers' Tower show a consistent decrease with proportional changes in bell size, while the Metropolitan carillon has a smaller and less distinct dynamic range. Also of note is the coupled mf and ff intensities for the upper range of the Metropolitan carillon. This implies that the carillonist is limited by the mechanism to create a contrast between mf and ff dynamic levels.

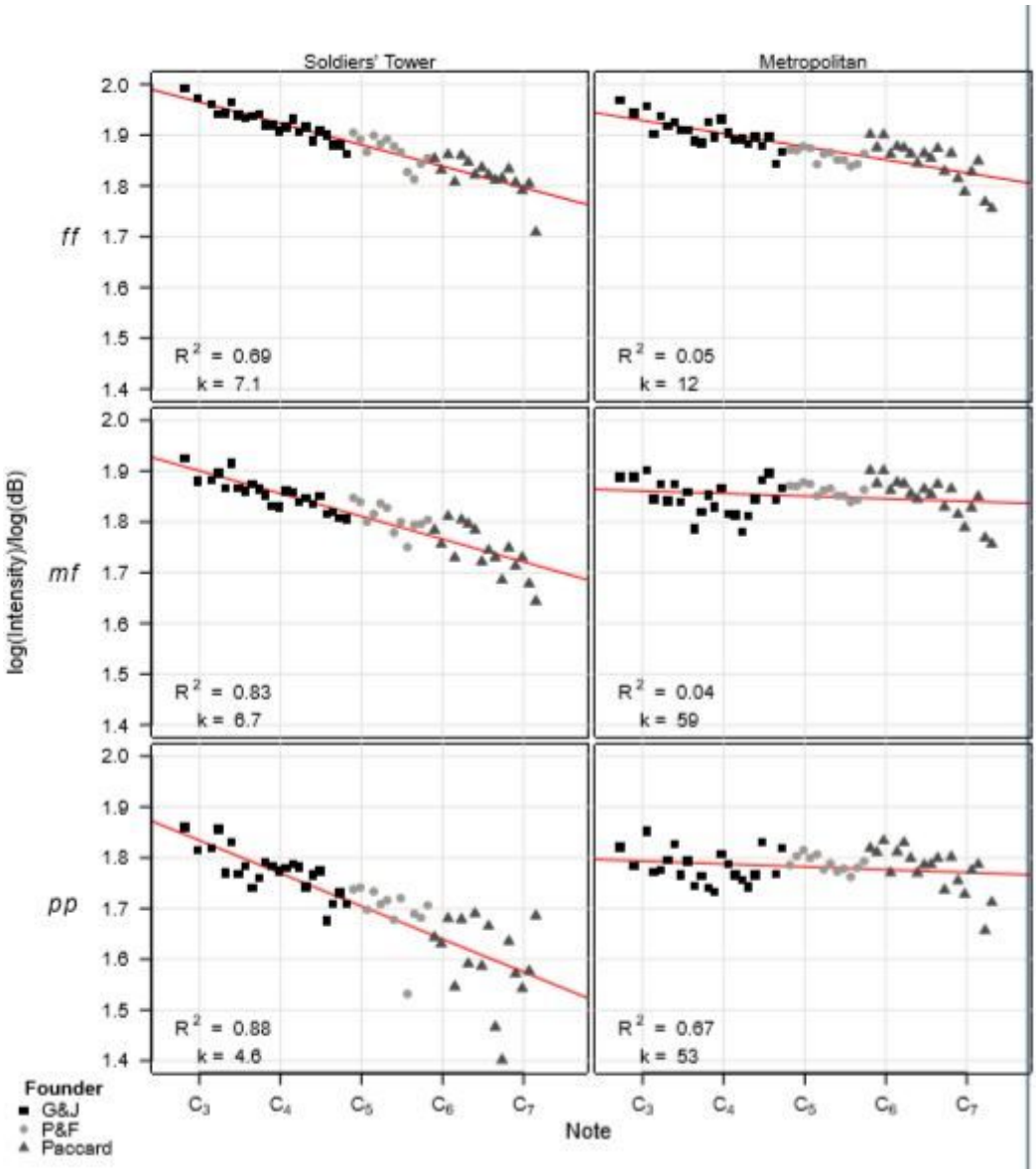

Figure 5

Summative bell intensity (total of the five main partials) log-log plots for Soldiers' Tower and Metropolitan bells at pp, mf, and ff musical dynamic levels. A highly linear fit (represented by R2 implies that there is a consistent decrease with decreasing bell size of the sound intensity produced by the carillonist. The carillon of Soldiers' Tower exhibits much more consistent behaviour for all three dynamic levels. k (in this case, the slope of the fitted line in red) is indicative of how significantly the intensity is dependent on the bell tone.

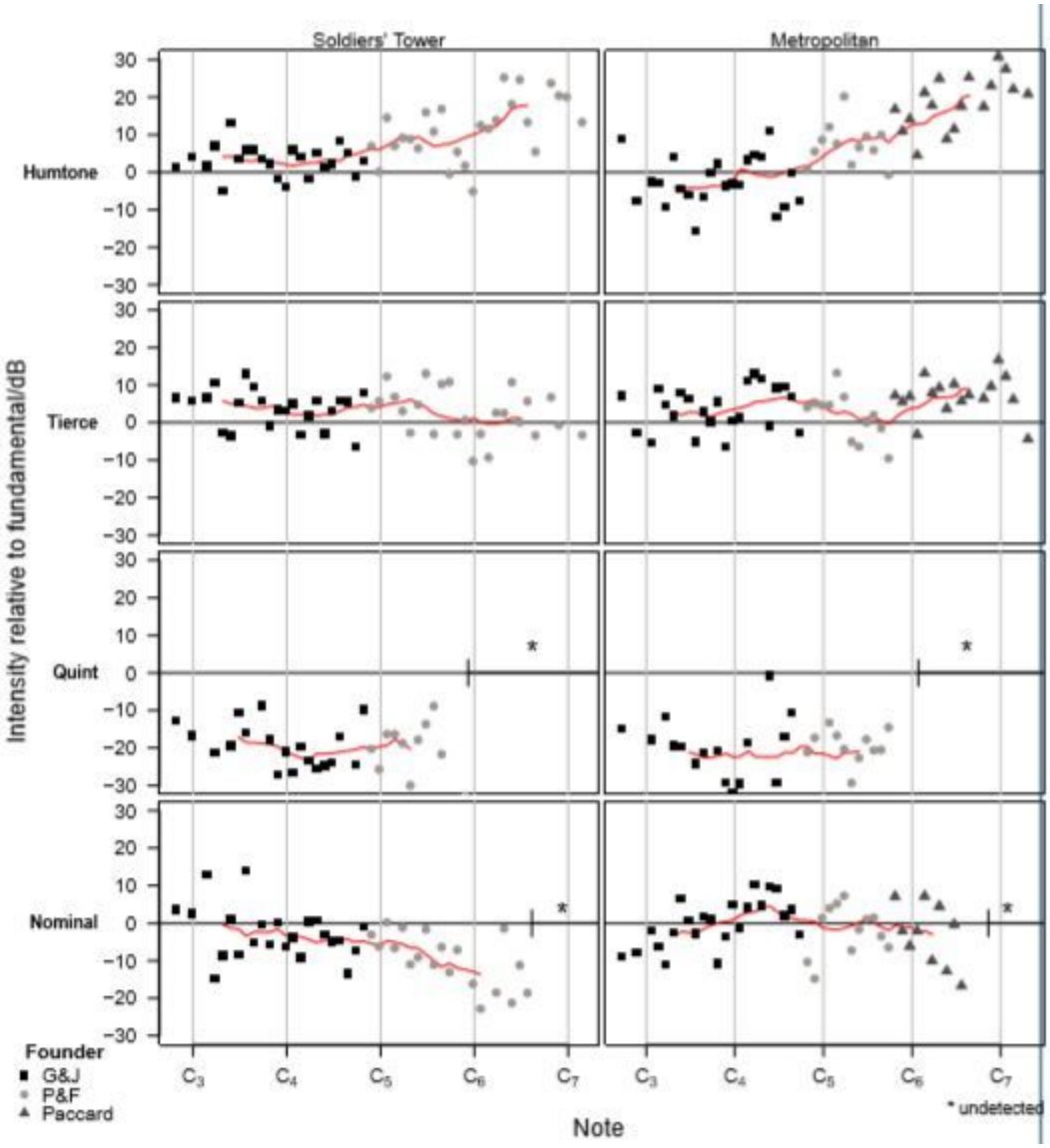

Figure 6

Partial intensities relative to the fundamental (F.R. = 2.000) overtone for Soldiers' Tower and Metropolitan bells. The intensity deviations were averaged across all three dynamic levels.

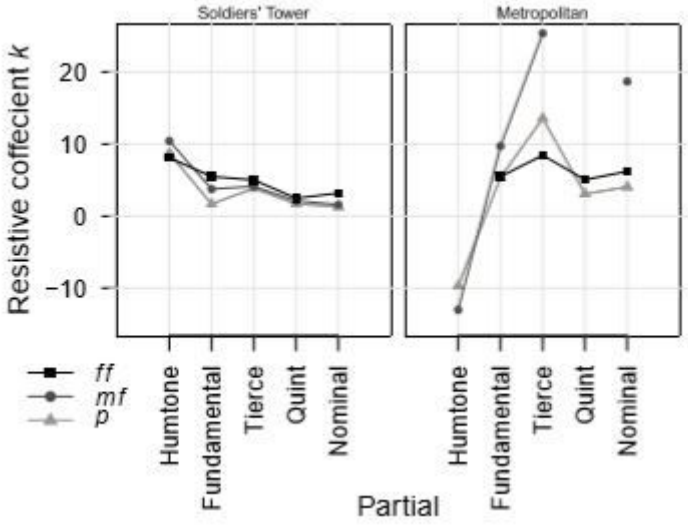

Figure 7

Resistive coefficients (k) for Soldiers' Tower and Metropolitan bells. k is indicative of how significantly the intensity varies proportionally with the bell size. As represented by values of k closer to 1 than its Metropolitan counterpart, the transmission system of the Soldiers' Tower allows for a greater range of dynamic response across the instruments range and higher contrast between dynamic levels.