UNISON DRIFT

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Definitions

Single String Unison - One string.
Double String Unison - Two strings tuned at, or close to the same frequency.
Open Unison Tuning - Tuning a complete note (trichord or bichord) for the purpose of using that as a reference to tune other notes, before moving on to tune other notes.
Shimming or Cracking the Unison - Muting one string of a trichord, and detuning the resultant double string unison, in a method that results in a very fine tuning of the trichord.

Preface

I have never found tuning to be easy. It took me two years to be able to hear the beating of a M3. But ever since starting to tune pianos, I have been fascinated by how difficult it is to tune equal temperament. I define it as progressively beating intervals within a beatless octave. (I defined a beatless octave in my June 2015 article on Equal Temperament)

In the June article I also define a sequence that should produce accurate equal temperament, at least it does on paper. However, in trying to tune a temperament in one pass, without refining at the end, I had been stumped. I would tune, what my ears would tell me, were beat speeds that bisected the beat speed windows that were being set up by the piano, and therefore should produce intervals that are progressive, but when finished, there were intervals that were not progressive.

This had me confused. I knew there was some drift due to adding unison strings together because of what I had read from Virgil Smith and Professor Gabriel Weinreich, and what I had observed in my own tunings. But it appeared to me that something else must be going on, and I was hoping it wasn't just in my head!

That's when I started noticing that, although I was tuning out Weinreich Drift by judging the double string unison before moving on, I was assuming there was no Weinreich Drift between a double string unison and a trichord.

I started measuring.

It turns out that the pitch of a trichord can change, up or down, when you add the *third* string to an already tuned double string unison.

Since I have started judging the *entire trichord* in my open unison tuning *before* moving on, my tunings have become more accurate and more efficient. Now, I have less refinement to do to my temperament, and because of the beat speed window method, my tunings are more accurate and precise than they used to be. I really used to have the feeling I was fumbling around a bit, guessing at things. Now, I am more confident with my tunings, and when something doesn't fit, and I have to guess what the problem may be, I have less unknowns.

I hope you have the same experience.

Mark

Introduction

This article discusses the final pitch of a trichord unison compared to the initial pitch of the single string and double string unisons.

The author has been searching for a more efficient aural tuning method and understanding unison drift has helped him choose better techniques that reduce the amount of refinement needed in an aural tuning, and have therefore resulted in more accurate, precise, and efficient tunings.

In the December 1977 edition of The Journal of the Acoustical Society of America, Volume 62, Issue 6, Professor Gabriel Weinreich wrote an article entitled "Coupled Piano Strings". In that article he mentions the resulting change in the frequency of a single piano string when coupled and sounded with another string of the same frequency.

Some piano technicians are aware of this and refer to this effect of drifting unison pitch as the "Weinreich Effect" in reference to this article and Professor Weinreich. However, some technicians explain this effect as resulting in a *drop* in pitch only.

According to the research contained in this paper, which conforms with Professor Weinreich's findings, the final pitch of a trichord can be lower, *or higher* than the initial pitch of a single string, and there is no way to predict which direction it will change, if at all.

The author has also found that the final pitch can be as much as 2 cents up or down. For any technician wishing to be more accurate in their tunings, this effect cannot be ignored.

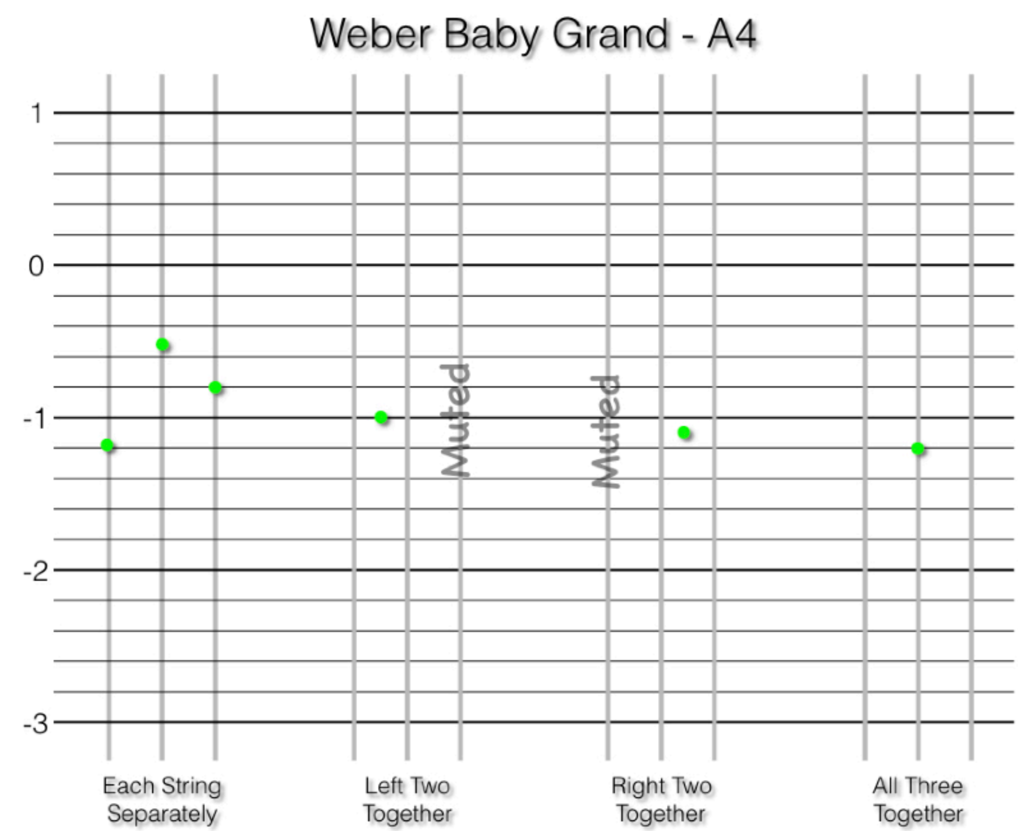
Method

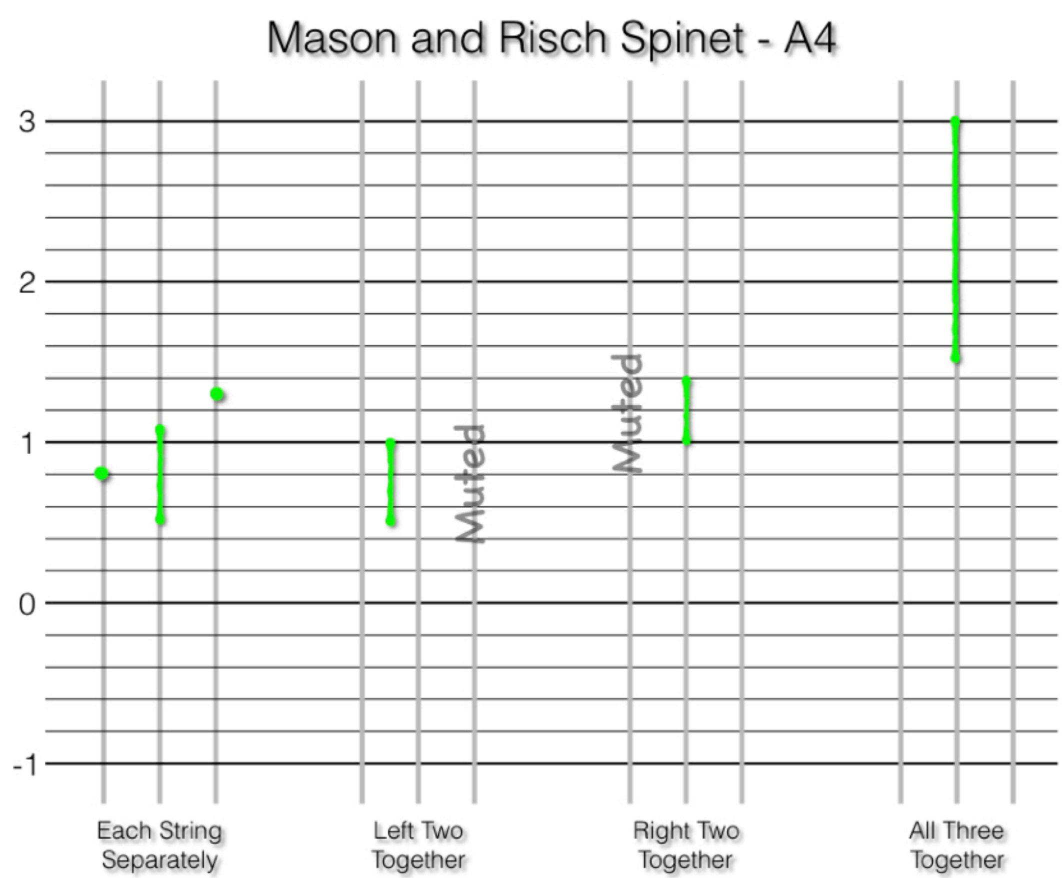
The trichord strings of various pianos were measured. Recordings were taken of the left string, the middle string, the right string, the two left strings, the two right strings, and the complete trichord. The iPhone app iStroboSoft was used to measured the frequencies. The cents offset was recorded compared to an arbitrary datum (zero).

Frequencies were plotted on a graph that showed the three strings of the trichord vertically. There were four trichords drawn on the graph, each representing the same trichord but repeated to show different measurements. The first trichord shows each string's independent frequency. The 2nd trichord shows the frequency of the left double string unison. The 3rd trichord shows the frequency of the right double string unison. The 4th trichord shows the final frequency of the three strings sounding all together.

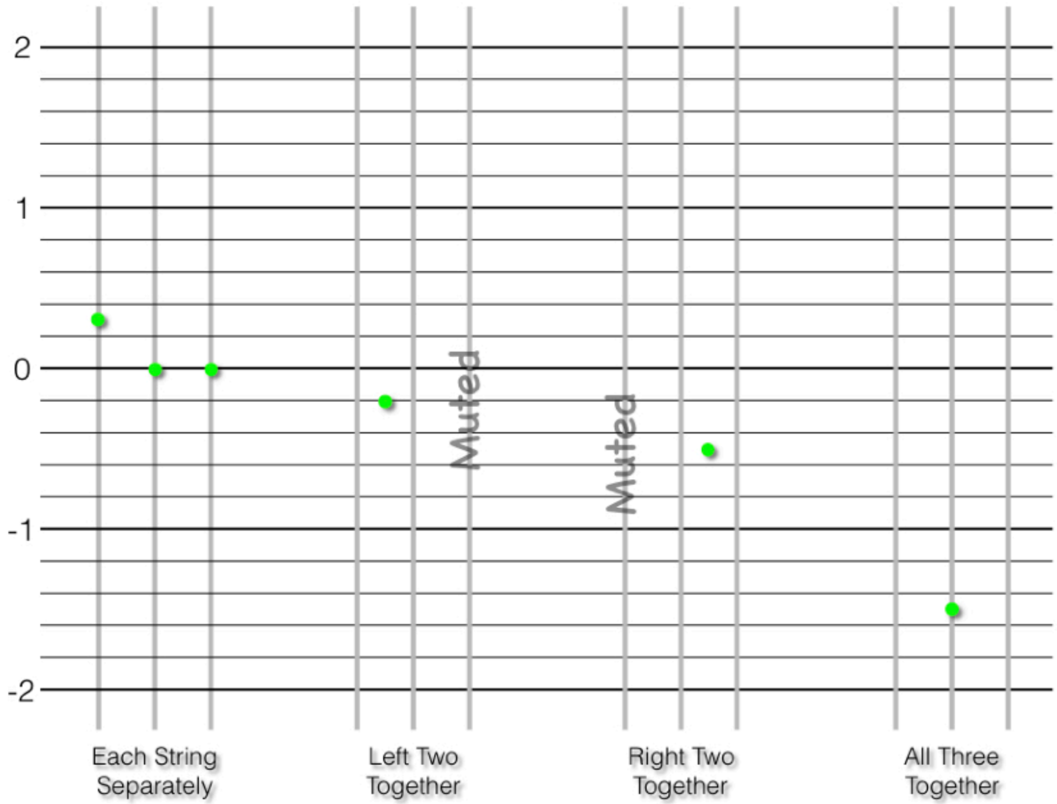
Some strings measured a steady frequency while others varied. Steady frequencies were plotted as a dot. Varying frequencies were plotted as a vertical line. Double string unison frequencies were plotted between the strings. The word “Muted” indicates which string was muted during the recordings. Trichord frequencies were plotted on the centre string.

The findings of seven different pianos and specific trichords, are shown below.

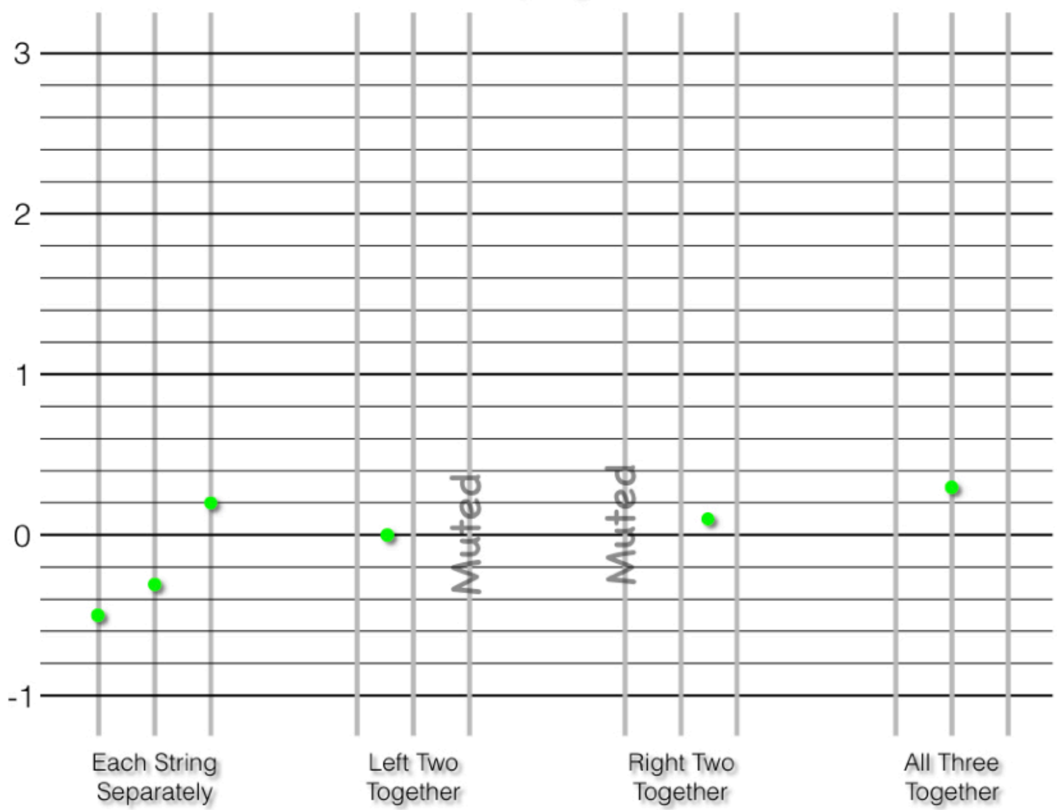


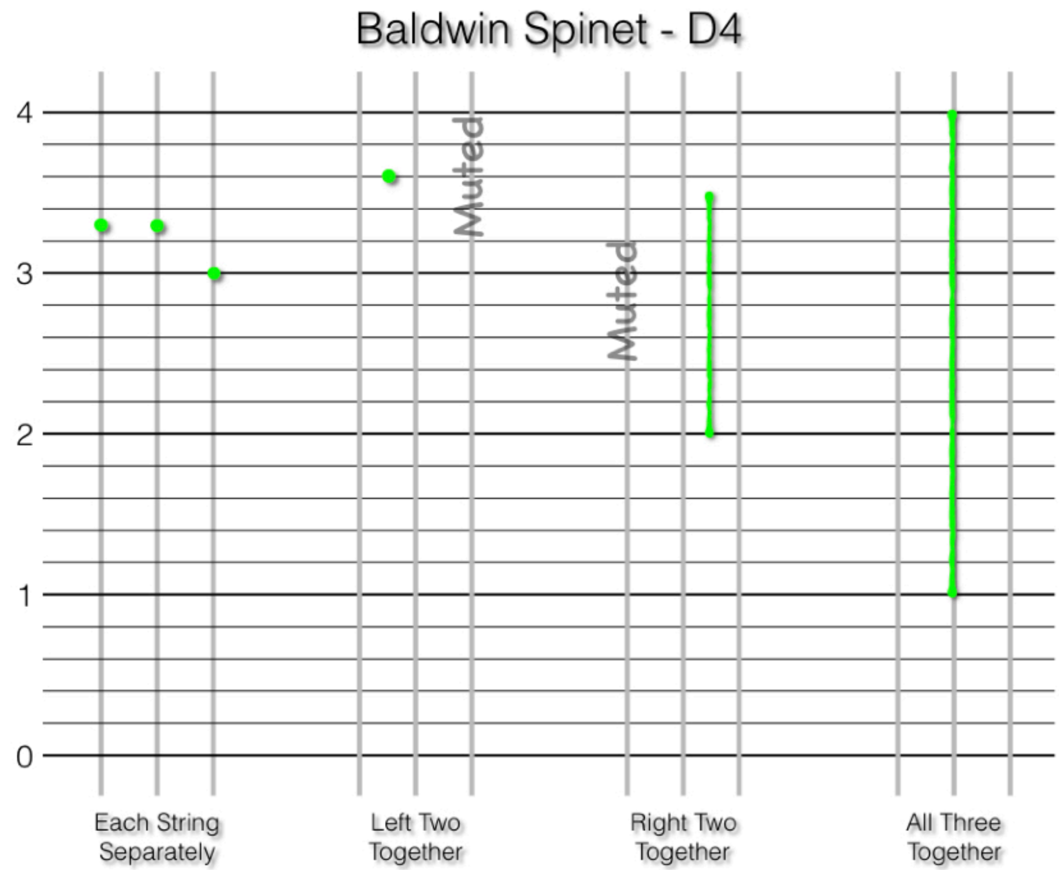


Wurlitzer Spinet - E4

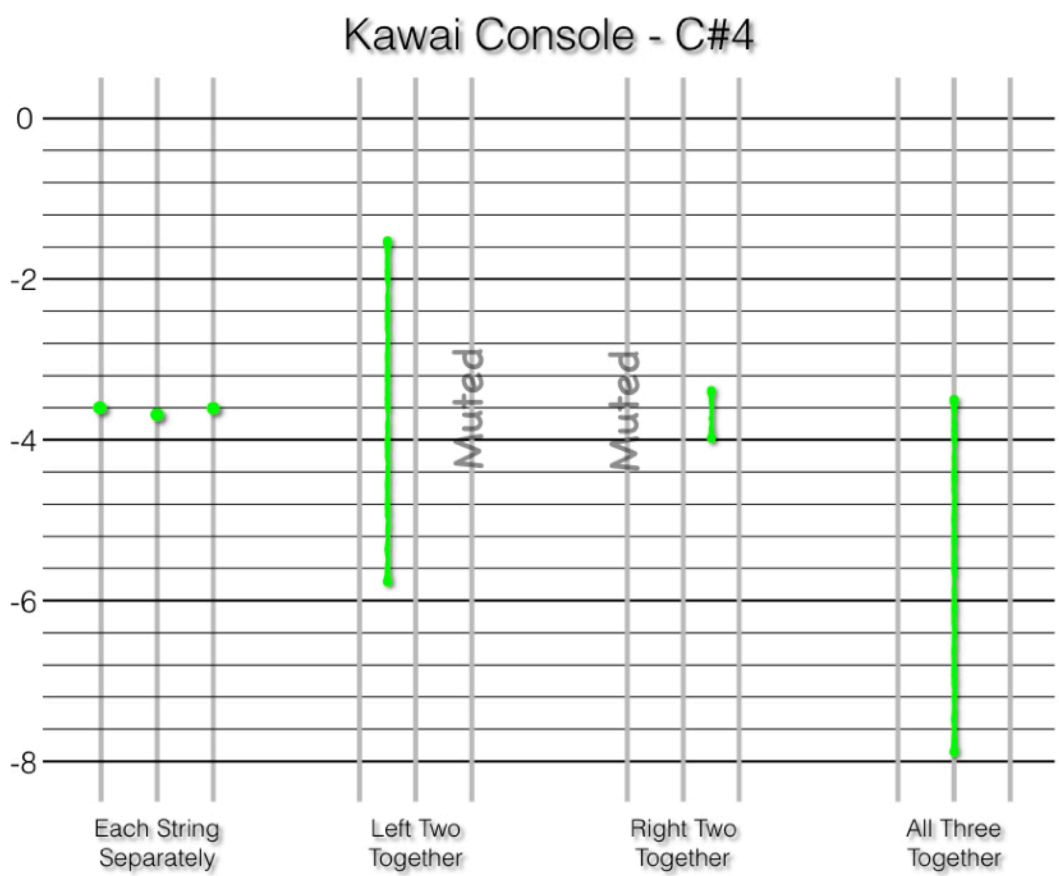


Willis Upright - A4

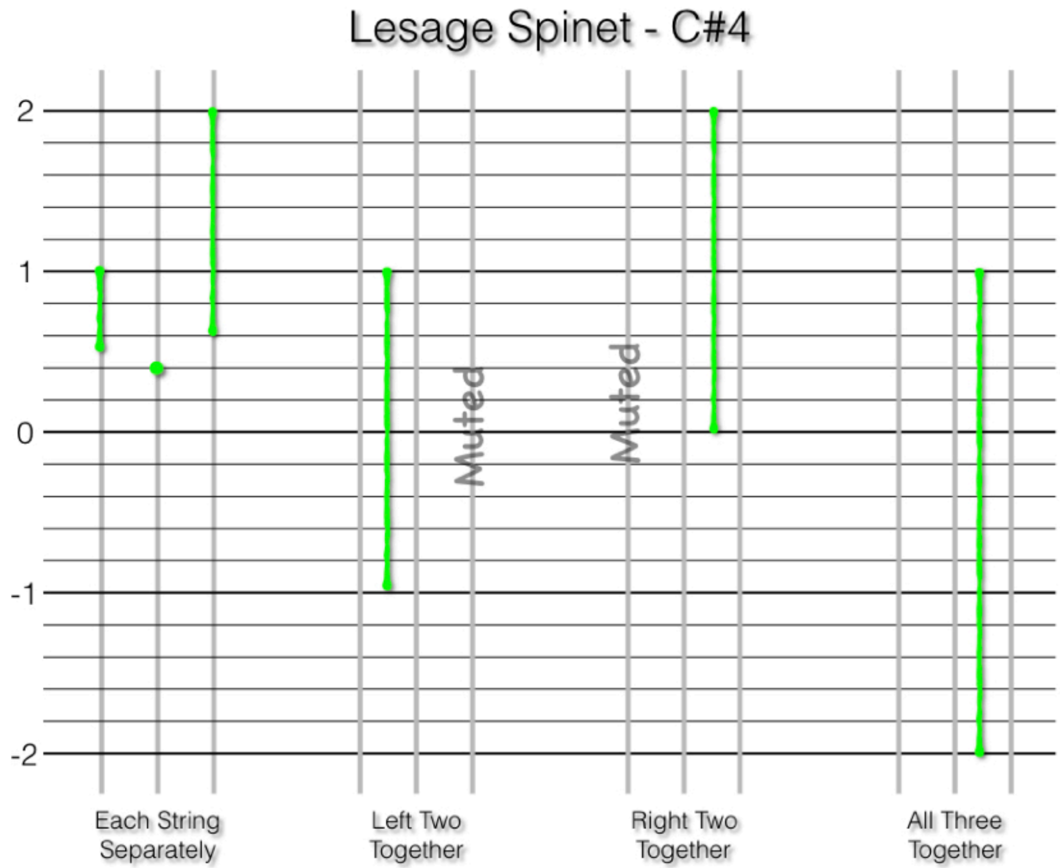




Baldwin Spinet - D4
4
3
2
1
0
Muted
Muted
Each String Separately
Left Two Together
Right Two Together
All Three Together



Kawai Console - C#4
0
-2
-4
-6
-8
Muted
Muted
Each String Separately
Left Two Together
Right Two Together
All Three Together



Results

Some piano's trichord's final frequency seemed to stay fairly close to the initial frequency of the individual strings. This includes the Weber Baby Grand and the Willis Upright. These findings, and their steady readings, help us to rule out any measurement or method error.

The Wurlitzer Spinet's trichord produced steady measurements but the final trichord measured a full 1.5 cents lower than the initial string frequencies.

The Kawai Console produced steady frequencies for each string, but the left double string and the trichord frequencies varied quite a bit. The left double string unison varied 4.3 cents. The trichord's measured frequency varied by 4.4 cents and averaged 2.2 cents lower than the initial string frequencies.

The Mason and Risch Spinet had two strings with frequencies that were steady and one that varied within 0.6 cents. The double string unisons were close to the initial single string frequencies, but the trichord varied 1.5 cents and averaged 1.3 cents *higher* than the initial string frequencies.

The Baldwin Spinet had good steady string frequencies. The left double string was steady at 0.3 cents *higher*. The right double string unison varied 1.5 cents but the trichord varied 3.0 cents!

The Lesage Spinet's trichord had strings whose frequency varied up to 2 cents with the final trichord varying up to 3 cents!

Conclusions

It is clear that the final frequency of a trichord, or bichord, cannot be assumed to be the same as the single string that we initially tuned. The final frequency may be the same, but may also be lower *or higher,* and there's no way to predict how it will change. Each note in a piano has it's own preference and will drift in its own way.

As well, the frequency spectrum of the final trichord may also be changed. The final trichord's frequency may vary up to 4.4 cents, even if the initial single string frequencies do not vary.

Recommendations

Tuning a piano is a difficult task. This research has shown that if we want to make it less difficult by being more efficient when we tune and if we want to focus our efforts on producing frequencies that are stable, we *cannot* trust the frequency of a single string.

If we want to be as precise and efficient as possible and not have to retune every note that drifts due to Weinreich Drift after we remove our mutes, then we need to make our judgement of the acceptability of the pitch of a note based on the way it sounds *as a fully tuned complete and pure bichord or trichord unison.*

We may also need to choose a particular section of the note's sustain as a reference if the frequency appears to vary over time, which it may, even if the individual strings have steady frequencies.

Open unison tuning techniques, where the entire unison is tuned completely before moving on, and where the fully tuned bichord or trichord unison is used as a reference to tune other notes, has the benefit that the frequency of the tuned open bichord or trichord unison will not change due to Weinreich Drift, because, if drift occurs, it has already occurred and you will not have to retune that note later for that reason.

Whether or not a tuner uses a mute strip, or even if they tune with an Electronic Tuning Device, they must reassess the pitch of the final open unison before moving on. This would seem to indicate that using a mute strip, even just for the temperament, may not be efficient if one is tuning just single strings first, then removing the mute strip, tuning all the strings, and expecting the frequencies not to drift. A better, more efficient method may to be to tune each unison as an open unison, using wedge mutes, and then assessing the pitch of the fully tuned bichord or trichord unison before going on.

For ETD users, it may be more accurate to tune all the strings of a note first, and then try to get the lights to stop by moving the trichord or bichord using the shimming method discussed below.

Also, if the pitch of the fully tuned bichord or trichord unison, is found to be off, then the tuner must change the pitch *without* listening to how the single or double string unison sound, or without looking at the ETD screen until all the strings of a note are tuned. There is a method of changing the pitch of a pure trichord or bichord called shimming or cracking the unison. This is the author's recommended technique for changing the pitch of a trichord or bichord. You do not check the sound of the incomplete bichord or trichord as you are tuning, you simply want it to change from where it was, to a new slightly higher or lower pitch, as a complete bichord or trichord.

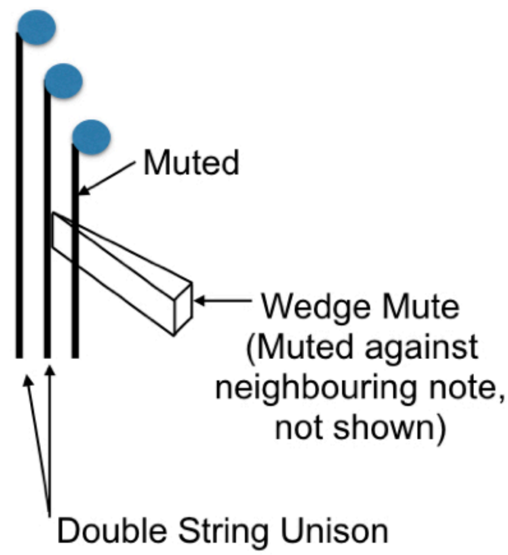
Shimming Unison Method

Use this method if you have a fully tuned bichord or trichord unison, and you need to raise it or lower it by the smallest amount. The resolution of this method can be as little as 0.3 cents.

Let's assume we want to lower the pitch of a pure trichord.

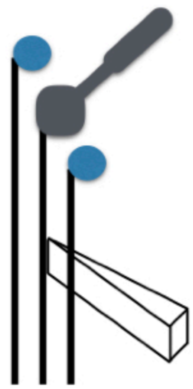
Method:
1) Mute one string. This produces a double string unison composed of the two other strings that are still free to vibrate.
2) Detune the resultant double string unison by applying as little force as possible to one pin. Listen for the unison to *change color.* We do *not* want to create a beat in the unison, just change its color, or tone.
3) Apply a similar force to the other pin of the double string unison and make the double string unison pure again.
4) Remove the mute. Apply a similar force to the third pin so that the fully tuned trichord is pure again.

Shimming a Trichord Unison



Step 1 - Mute off one string.

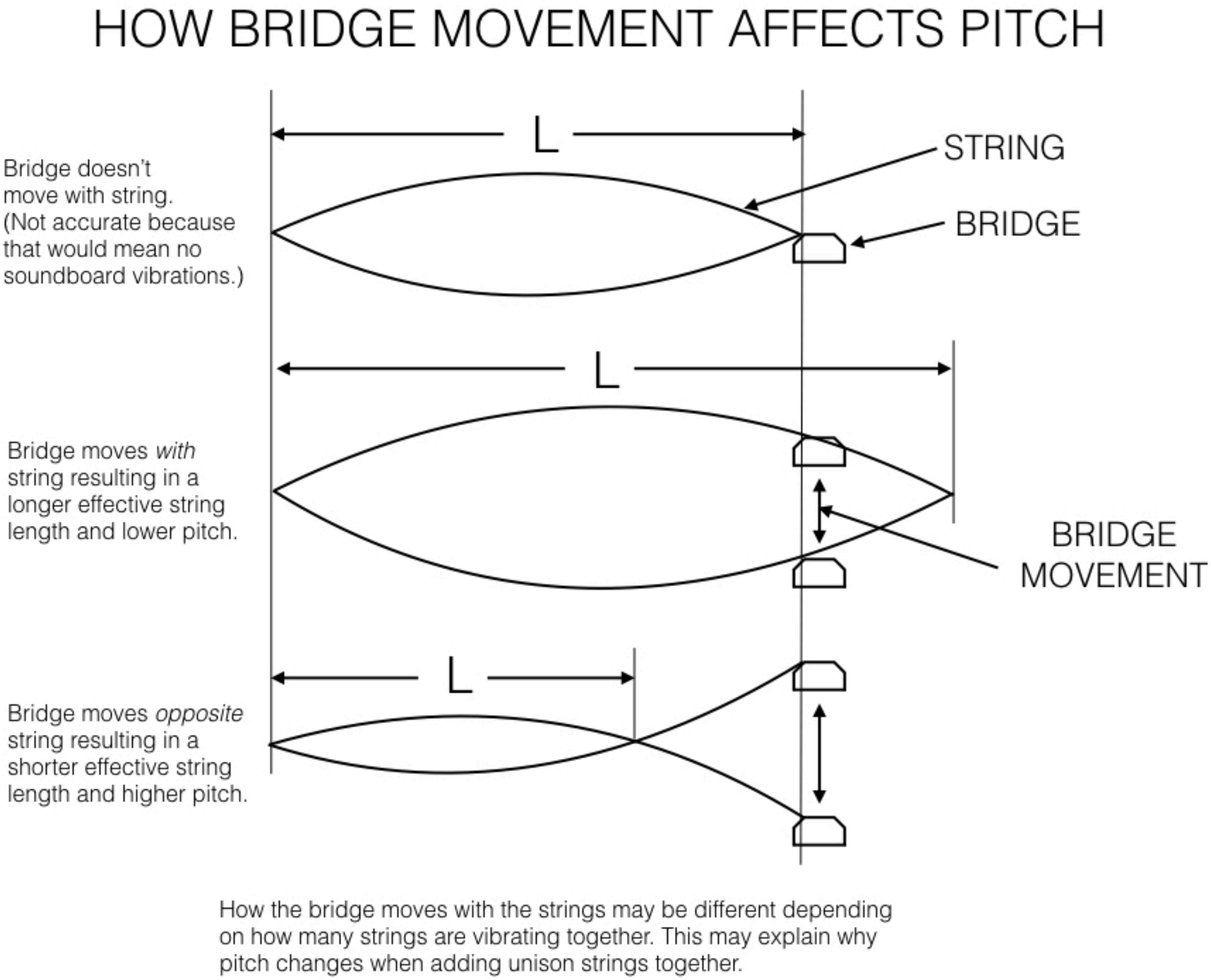
Step 2 - Detune the Double String Unison
in the direction you want to go.



Step 3 - Retune the Double String Unison pure
by turning the other pin.

Step 4 - Remove the mute and tune the trichord pure.

Possible Explanation of What is Happening



Source: The idea of unison drifting and the inspiration for this study and the concept of the diagram above was taken by a paper written by Professor Gabriel Weinreich entitled. "Coupled Piano Strings", The Journal of the Acoustical Society of America **62**, 1474 (1977). https://doi.org/10.1121/1.381677

Final Words

Piano tuning is difficult. The most difficult part may not be the piano, not Weinrich Drift, not tuning lever deformation, not stability, not inharmonicity, etc.

The biggest problem in learning to tune pianos may be our own arrogance. How can one justify the time and energy to look for and learn new methods when there doesn't seem to be a need?

To find out if there is a need, try measuring tunings. Try to identify what assumptions are being made, then prove them wrong, and then find better ways to tune. The result of this kind of self learning process is that tunings become more accurate, more precise, and more efficient.

Maybe there is a belief that the tunings are good enough. But what about when there is a time restraint, or noise in the environment? What about when you get "that" call? You know the one. "We have a piano that needs to be tuned. So-and-so [your mouth drops] is coming to town and we got your name from someone. We've never used you before, but we're in a bit of a bind."

Will a "good enough" tuning be good enough for this one?

One way to get better than "good enough" is to search out areas where tunings might be lacking, like unison drift, and learn what others have done to deal with it.