Lost in History: the Keys of Tango Music **Age Akkerman**

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Jens Ingo and others did a great job in making us aware that the speeds of many tangos we listen and dance to are not correct. The problems stems from the 78 rotations per minute (RPM) disks, which actually are we-don't-know-somewhere-around-78 RPM disks.

The result is that exactly the same original recording from one record label is faster than another record label. If you compare a song from three different sources you may find three different speed levels.
And not only the speed is different, but also the height (pitch) of the tones, because if you play a disk faster the pitch goes up (the Mickey Mouse effect in some tangos played too fast).
Only in the recent years, it became possible to speed and pitch independently (time stretching or pitch shifting) with software programmes. I think we can safely assume this has not been done to the recordings on the CDs.
Finding the right preamplification is another problem in digitizing 78 RPM disk, but as far as I see, this is about equalization and affects the volumes (dB) but not the heights of the tones.

Detecting the frequencies to find the original speed?

I'm not a tango purist and I admit to sometimes changing the speed on purpose, to make them better danceable. But if I have 3 different copies of one song, all three different in speed (and thus length and pitch\tone), which one is right? Or none of them? And is maybe my whole tango collection 'out of tune'?

I started looking at the pitch. Maybe the tone height would give me a clue. Years ago, I tried to transcribe a tango, to write the score down. This is very hard and I remembered using Transcribe software to show the frequencies that are played.

First, a bit of explanation about frequencies, semitones and cents
A Standard Tuning (ST) has been agreed internationally, saying that a frequency of 440Hz (Herz) is the A above the middle C (called C4, the fourth C key on a standard piano). The next semitones (next key on the piano) is B ♭ (B flat), which has 466.16 Hz. One octave is 12 semitones.
The distance between two semitones is divided into 100 cents. The deviation of a frequency that is not exactly on one tone in Standard Tuning can be measured in cents.
A deviation of 50 cents means that the sound is exactly halfway between two semitones. This is on the piano: just between two keys. A deviation of 100 cents means that you are exactly on the next semitone, while more than 100 cents means further than one semitone away.
If a tone has a frequency of 453Hz, it is just in the middle between B ♭ and A. You can describe it as either A +50 cent or B ♭ -50 cent.
The key (e.g. A major or minor) is the basic tone of the piece, often the (soft) last note of a tango or of a phrase.

I found Transcribe and searched manually for the key tone of several tango recordings.

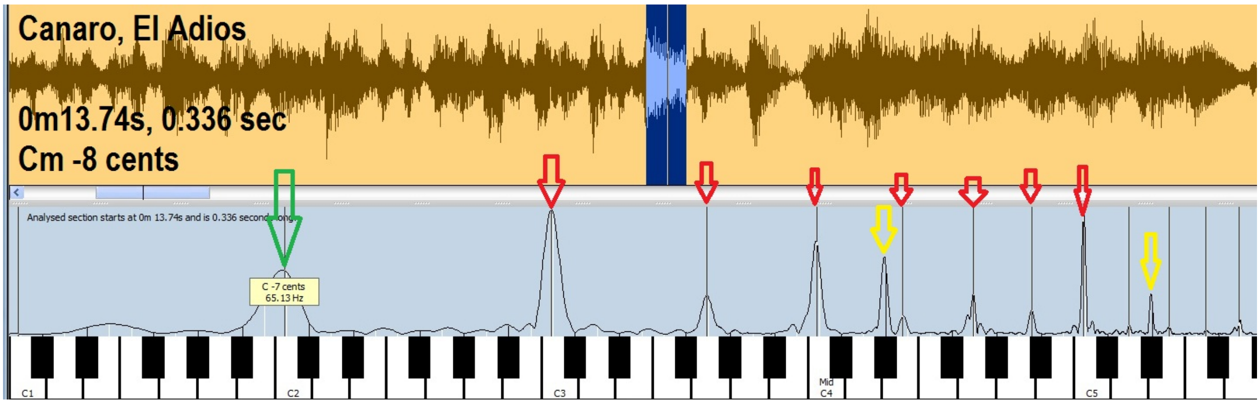

Figure 1. Using Transcribe to find a note/frequency

As Figure 1 shows, each tone has a series of overtones (I indicated them with arrows). The green arrow is the frequency I selected (C -8 cents) of which the overtones (red arrows) fits best with the frequencies of this fragment. The yellow arrows show that actually this is a C *minor* chord (E ♭ instead of E).

I hoped to detect that many records would be in-tune, and so I could unmask their false clones because they would be out of tune. But... the results are all over the place. Everywhere in between of the keys. It looks like a random distribution.

This is very strange. Did Troilo instruct his big orchestra: Let's play this tango today somewhere in between A and B ♭ ?

To make the story more complicated, the Standard A=440Herz has not always and everywhere been the Standard. In France, since 1859 the Standard was A=435Hz. At the same time in the UK and the US it was 440Hz. There also was a different "orchestra tuning". In 1941, an international agreement set the Standard A at 440Hz. At the time when the bandoneons where developed in Germany, they applied the French standard of that moment of A=435Hz (called Normales Abstimmen, "NA"). However, they also tuned bandoneons in so-called Orchester Stimmung (OS) of 440Hz. According to some, bandoneons for export to Argentina where tuned in 440Hz. However, many bandoneons seem to be labeled "NA" and around 1941 these bandoneons have been revised, and tuned to the new standard.
And not only this... Bandoneons are often tuned a bit higher, to 442, 443 or even 445Hz. It compensates for the decrease of pitch that happens if you play the bandoneon loud. It seems to give problems sometimes if an Argentine with a high-tuned bandoneon (445Hz) comes to play with a piano in Europe. Many European orchestras tune to 442; in the US they do this as well.

Data set for testing
Being a DJ, I have been collecting many tangos from many sources, resulting in a big collection ready to test. After deleting all the exact copies from the data set, I have 30550 records, including many somehow different copies of the same songs. Some 13000 records are the core collection that is carefully tagged with correct year data etc. The rest, around 18000 records, is a backup pile of unchecked files, often missing correct tags like the year. So, the data are dirty, the tuning goes all over the place, but let's see...
After analysing a few records manually with Transcibe, I ran them all through Beatunes (thanks for

your suggestion Trud!) to find the Key and Tuning (the deviation from Standard Tuning A=440Hz). Manually checking, I found some errors in the resulting keys and tuning from Beatunes. No tuning could be calculated for 3165 records, leaving 27385 records. For 21674 records, both year and tuning are known.

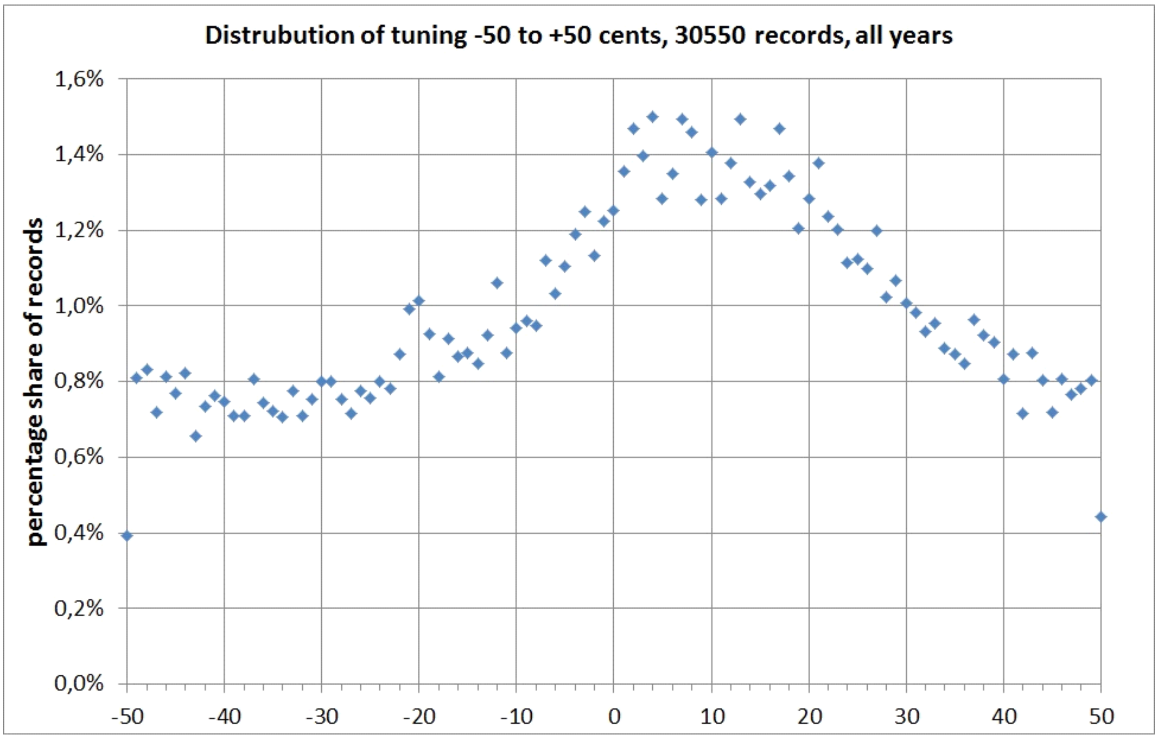

Figure 2. Deviation from A=440Hz tuning in cents, 30550 records, all years

Figure 2 shows the distribution of records over the range -50 cents to +50 cents. The distribution is indeed all over the place. Only 25% of all records are within the range of -10 and +10 cents , which is called a just-noticeable difference. But the top of the distribution is between 0 and 20 cents (29% of all records), showing the tendency of the tuning to be higher than 0.

Eliminating extremes

Figure 2 also shows that many records have extreme values. A value of -50 or +50 cents is exactly in between two semitones. This might distort the conclusions, because a deviation of -45 from A could also be interpreted as a deviation of +55 from B ♭ . Therefore, I discard from the data set all the 4209 records with tuning deviation more than 40 cents and less than -40. This “Reduced data set” contains 23176 records.

Discarding these items had no significant impact on the overall figure. The total average deviation increased from +2.43 cents for all records to +2.72 cents for the reduced data set.

Knowing that the tuning of orchestras and bandoneons has changed, I calculated the average deviation of tuning per year using this reduced data set.

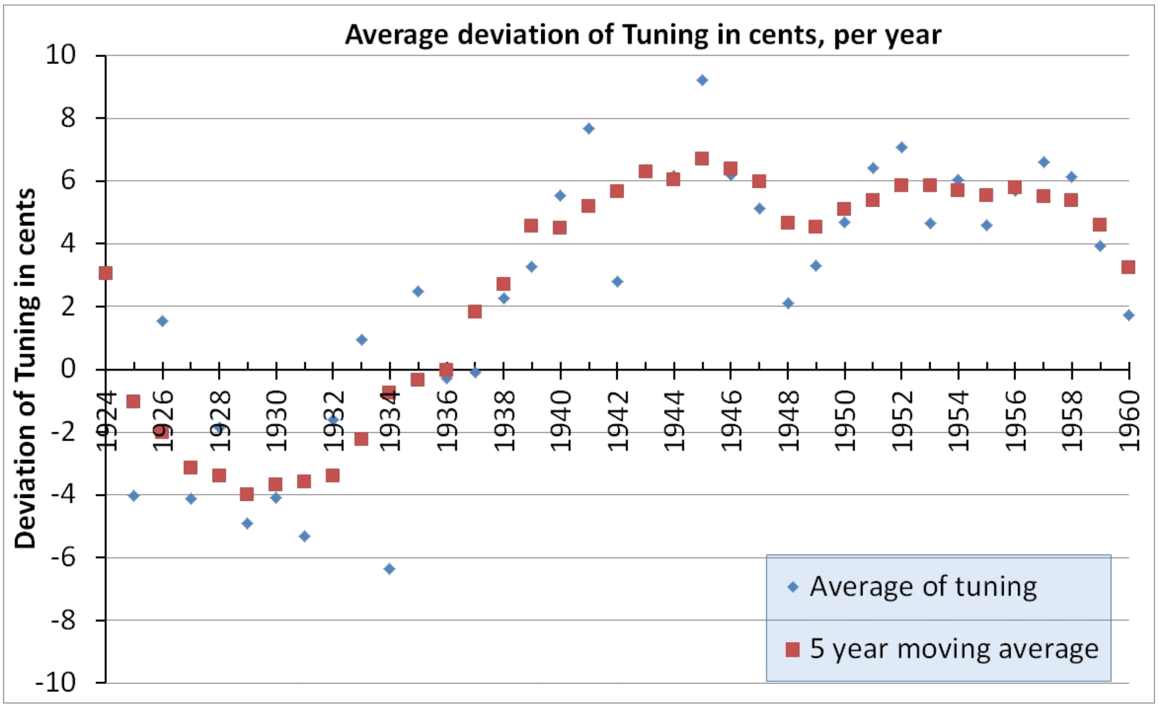

Figure 3. Average deviation of Tuning in cents, per year, 1924-1960, reduced data set

Now, what do we see in Figure 3? I was surprised that this trend came out so clearly. It seems to tell that we can indeed see in the data that the tuning has changed. It goes very well with the story of old bandoneons being tuned lower and then revised and tuned upwards, while new instruments were sold in the new tuning.
What we see here is not the bandoneons, but the whole orchestra. But the tuning of all instruments must have been adapted to each other and relatively stable. Re-tuning a bandoneon is very expensive and takes a lot of time. Also completely re-tuning a piano is not very practical.

Now we can calculate an average tuning for different periods:

Table 1. Average tuning deviation from Standard Tuning in cents for several periods

years	*Average tuning deviation in cents*	*# of records*
all	**+2,72 cent**	**23176**
1927 - 1937	-2,83 cent	4609
1938 - 1948	+5,54 cent	5677
1949 - 1959	+5,50 cent	3994

A deviation of 5 cents is quite small. A tone of 442 Hz is already A+7 cents. This makes me think that if we a looking for a reference, we could in fact just take A=440Hz.

No, I didn't start re-tuning my complete tango collection. But *if* we would like to do that, table 2 shows how much slowing down or speeding up would be required (assuming we want to keep the pitch/tempo rate).

Table 2. From deviation in cents to required correction and resulting tempo change in BPM

Measured deviation from Standard Tuning					Required correction to Standard Tuning			
semi-tone	**cents**	Ratio* actual/ST	%change	example ST A=440Hz	cents	ratio* ST/actual	**%change**	Example 60 BPM change
	0	1	0%	440	0	1	0%	60
	5	1,0029	0,29%	441,27	-5	0,9971	-0,2884%	59,8
	-5	0,9971	-0,29%	438,73	5	1,0029	0,2892%	60,2
	8	1,0046	0,46%	442,04	-8	0,9954	-0,4610%	59,7
	12	1,0070	0,70%	443,06	-12	0,9931	-0,6908%	59,6
	20	1,0116	1,16%	445,11	-20	0,9885	-1,1486%	59,3
	-20	0,9885	-1,15%	434,95	20	1,0116	1,1619%	60,7
	30	1,0175	1,75%	447,69	-30	0,9828	-1,7179%	59,0
	-30	0,9828	-1,72%	432,44	30	1,0175	1,7480%	61,0
	40	1,0234	2,34%	450,28	-40	0,9772	-2,2840%	58,6
0,5	50	1,0293	2,93%	452,89	-50	0,9715	-2,8468%	58,3
	60	1,0353	3,53%	455,52	-60	0,9659	-3,4064%	58,0
1	100	1,0595	5,95%	466,16	-100	0,9439	-5,6126%	56,6
-1	-100	0,9439	-5,61%	415,30	100	1,0595	5,9463%	63,6
	120	1,0718	7,18%	471,58	-120	0,9330	-6,6967%	56,0
1,5	150	1,0905	9,05%	479,82	-150	0,9170	-8,2996%	55,0
octave	1200	2	100%	880,00	-1200	0,5	-50%	30,0

*ratio: calculated from cents: 2^(value of interval in cents/1200); or from frequencies: target freq/actual freq. The required % change is this ratio-1.

Table 2 shows how the measured deviation in cents can be converted to a percentage by which the speed/pitch of the recording should be corrected to tune it to Standard Tuning, e.g. with Audacity.
It also shows the resulting tempo when the tempo before the correction would have been a typical 60 beat-per-minute (BPM). A slowing down from 60 to 56 BPM (-6,7%) is quite a change of mood, but also to 59 (-1,7%) or certainly 58 (-3,4%) is a perceivable difference.
As you can see in Table 2, tuning the bandoneon 442 or 443 is only 8 or 12 cents away from standard tuning. The old tuning at 435 is -20 cents away from standard tuning.

How could we use this?

A typical correction could be reducing the speed/pitch of a song with a deviation of +30 cents. If we assume that the original has been recorded in standard tuning, a deviation of +30 cents means the tempo of the original was 1,72% slower. Taking for example a typical tempo of 60 BPM, this would be reduced to 59 BPM.
Some recordings are not a bit too fast, but way too fast, e.g. 8.2%, as found by Jens Ingo. This implies the pitch was +148 cents, around 1,5 semitone too high. So, the slowing down skips one semitone and goes to the standard frequency of the next semitone.
We can also check in the original score, in which key the piece is written. However it might have been transposed to another key, e.g. to make it fit better to the range of a singer, but that would probably be more than one semitone further.

Often and seldom used Keys

Knowing which keys are seldom used (because they are difficult to play in on some instruments) and which ones are very often used, helps indicating what has been the original key, and thus whether you would slow down or speed up a song (and how far) to bring it back to the original key.
Beatunes doesn't always give the correct keys. One reason is that tangos often have (temporary) modulation to a closely related key (e.g. the corresponding major/minor, from Am to C). Therefore, I created a new data set, consisting of the first 25 seconds of 10.500 records. Beatunes found the key and tuning of 9392 records. I combine the major and minor of one key, instead of the corresponding keys (e.g. D and Bm), because their shares fit much better. An equal spread among the keys would give a share of 1/12=8.3% for minor and major of a key together.

Figure 4a shows that D/Dm, G/Gm, C/Cm, A/Am, E/Em, F/Fm and B/Bm are most frequent. Together they cover 79.8% of the records. The share of B♭/B♭m and A♭/A♭m is quite low.

Figure 4a. Share of keys (first 25-seconds data set)

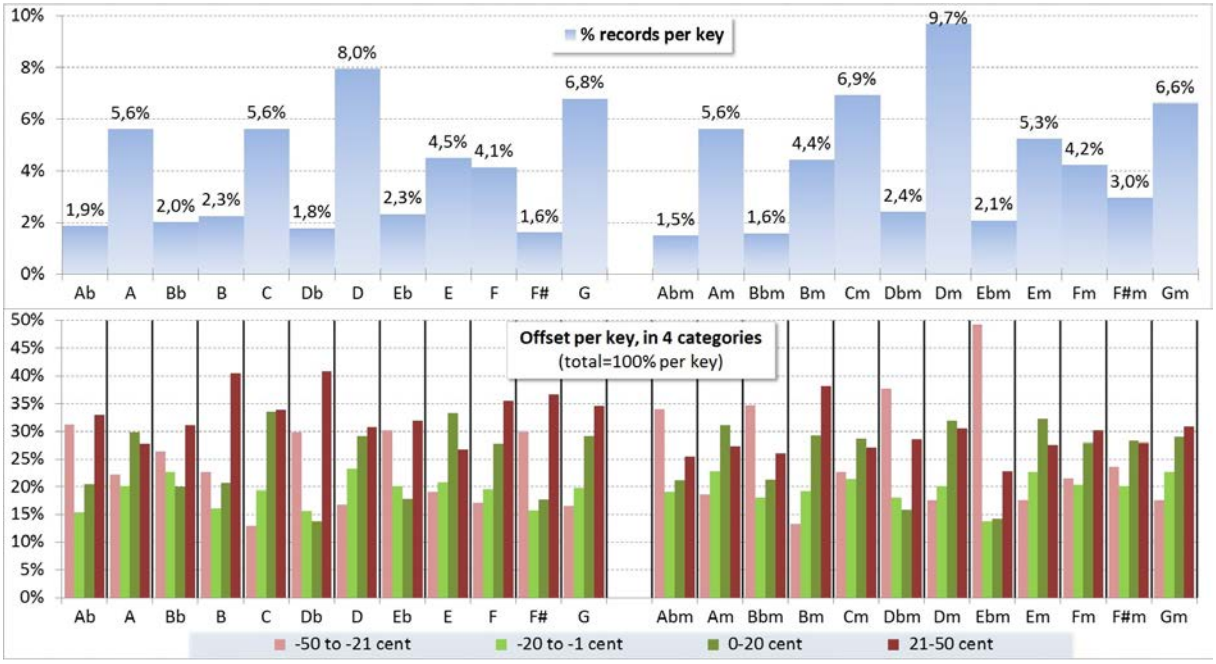

Figure 4b. Share of records in 4 categories of deviation from Standard Tuning (per key =100%)

The first column of Figure 4a shows that only 1.9% of the records is in A♭. Figure 4b shows the offset of all records in A♭.

The 1st, light-red bar: 31% of all records in A♭ has a deviation between -50 and -21 cent.
The 2nd, light-green bar: 15% has a deviation between -20 and -1 cent.
The 3rd, dark-green bar: 20% has a deviation between 0 and 20 cent.
The 4th, Dark-red bar: 33% has a deviation between -50 and -21 cent.
High shares in the red bars indicate a higher probability that this is not the original key. Only 2.1% of the records is in E♭m and many of them are too low, have a high negative offset (-50 to -21 cent), indicating they might actually be in Dm but too high (E♭m -40 cent is the same as D +60 cent).
The often-used keys have lower red bars: the chance that this is the correct key is higher.

It would be useful to hear from e.g. bandoneon players about the keys they avoid or prefer. To be continued…. **Thanks for reading! What now? Building a perfect C minor tanda? Any suggestion, remarks, comments? Please! -> ageakkerman@gmail.com**