*Digital Musicology - Arthur Parmentier & Albane Descombes*

# Influence of instrumental practice on note recognition: a study on musicians at EPFL

# ML4 : Final analysis and results

## 1. Research framework

### a. Question

The question that the present report addresses in a limited extent is the following : how does the instrumental practice influence the ability of a musician to recognize notes by hearing ?

### b. Prior intuition

The intuition behind this question relies on the understanding of the music instrument as an interface between the musician's ideas and the musical content. From this conceptualisation, one can think of several elements and features of the musical instrument that would lead to different representations of the wanted musical content on the given instrument. Typical examples could be pianists having a visual, graphic representation of the notes, mapped onto the keys whereas a trombone player would think the musical idea with respect to the movement of the arm and the tension of the lips required to produce a given note.
One can think that some representations are linked more closely to tone recognition capabilities, whereas others would rely more on harmony understanding, intervals visualisation and other features that do not involve a direct and absolute knowledge of the tones produced by the instruments. As the instrument shapes the way we produce music, one can think it also shapes the way we think the music, for instance by prior knowledge of the exact pitch that is going to be produced by the instrument or not.
Another aspect of the question that appears interesting to study is the capability for musicians to recognize note for several timbres, especially comparing their capabilities when hearing the timbre of their own instrument with respect to other timbres.
Finally, it can be expected that the musicians' internal representations of the musical content depends not only on the instrument itself as an interface but also on the context in which the instrument is used. One would think that musicians who usually improvise put greater attention to the content of their production, such as the notes themselves, and try to conceive it *a priori*, giving much more weight to capabilities such as absolute pitch hearing than other musician who would read scores.

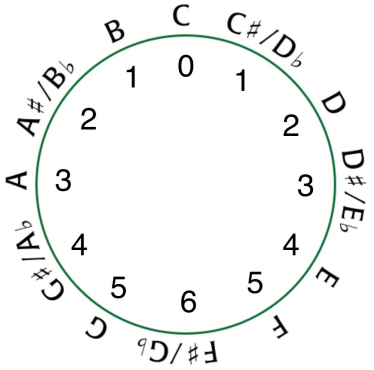
## c. Assumptions

During the following report, several assumptions and hypothesis are made. First, we assumed during that musicians around EPFL campus are familiar with modern, Western Chromatic scale, without differentiation of notes with an interval smaller than a whole chroma (no distinction between d# and eb in the results).
Then, we also used virtual instrument generated sounds during the test phase, assuming that the familiarity differences of the participants with the presented sounds would remain as relevant as with natural sounds.
Moreover, octave equivalence is assumed so that the participants do not give the octave number of the tones: measures of distances from their answers to the presented tones therefore lie between 0 and 6.
Finally, we assumed that the methodology proposed is indeed able to give a measure of the phenomena that represent local, context-free tone recognition without measuring any artifact of relative, context-sensitive pitch recognition. More precisely, we assumed that the given 8 seconds window for the participant to give his answer allowed only people with direct recognition systems such as absolute pitch recognition to give a correct result, whereas people with relative pitch derivation would sometimes take more time to process the large interval, so that it is hard to rely during the whole test on these methods.

# 2. Data collection

The collected data consisted of both results from an individual questionnaire on the participants musical habits, background and self-evaluation and of series of tones with different timbres - sin, piano and a particular instrument of the same acoustic category as the participant's instrument - as well as the participant guesses of the notes that have been presented to him during the series. All the data are collected by hand (both during the questionnaire and the hearing test) by one of the supervisors of the study.
Overall, the data contains results from testings with a total of 36 different musicians around the campus, with ages from 18 to 10 years old (mean = 22,6), a mean music study time of 15,5 years, sorted in the following instrumental categories: 16 fretless string players, 13 percussion players, 7 wind players.

# 3. Final results and interpretation




We measured the distance between pitches according to this chromatic circle, in that way the distance could be at most of -6 or 6.

# a. Total distribution of the error

The total counts of the distances between the presented tones and the given answers independently of any factor is shown on the following figure:

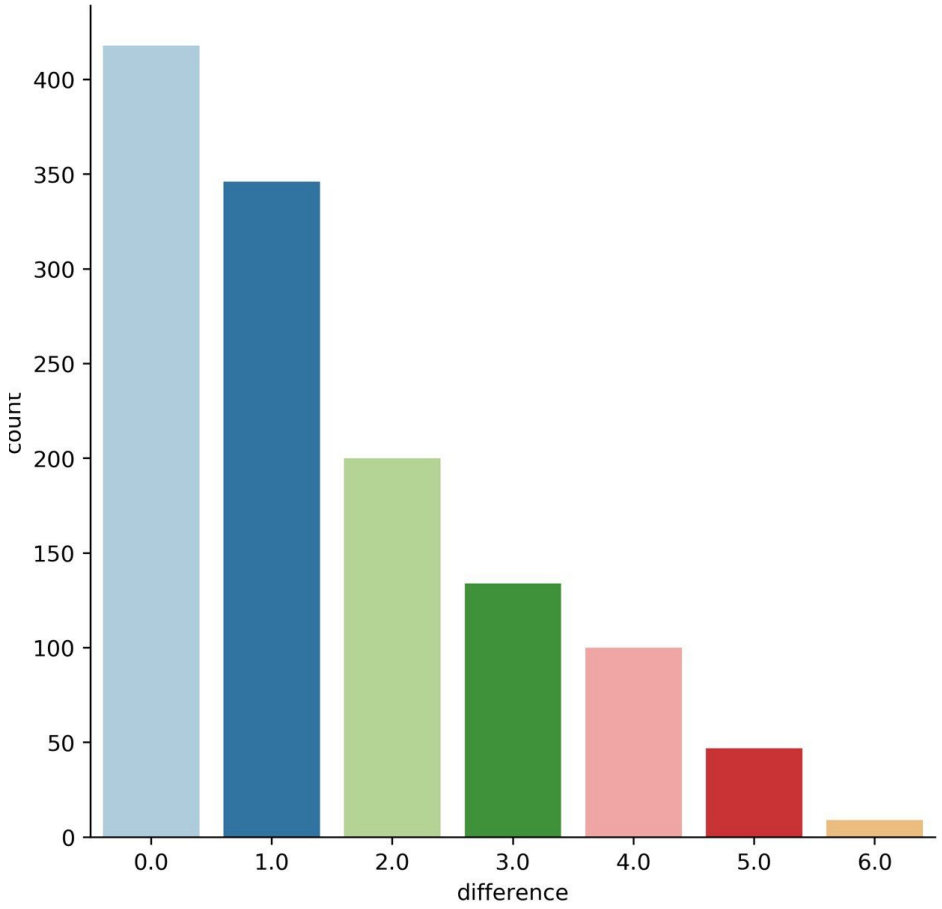



*Fig 1 : counts of responses given, by distance from the actual answer in terms of pitch.*

The results show that on average, the participants performed better than chance, given the trend for correct answers (difference of 0 semitones) and close answer (difference of 1 and 2 semitones). The average difference is indeed 1,46 semitones, which is clearly less than the expected average for answers based on luck: 3 semitones. It is interesting to note that the counts for differences of 3, 4 and 5 semitones is decreasing: even though these answers can be thought to rely on pure luck, the observation that they are not uniformly distributed let us think that these answers still relied on a certain sense of the distance between the provided answer and the presented tone. The very low counts for a distance of 6 is also explained by the fact that only one possible answer would result in this distance, whereas distances from 2 to 5 can results from 2 possible answers given the assumption of octave equivalence.

As a control of the quality of the result, one can compare the participants' self evaluations to the counts of the differences, as shown in following figure:

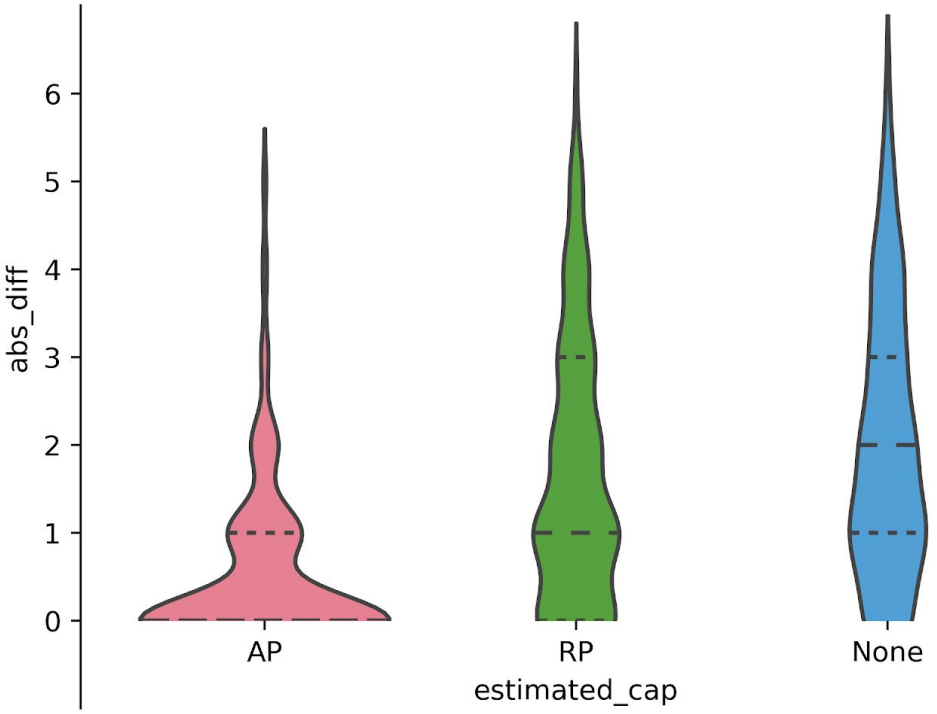



*Fig 2 : distribution of difference between the given responses and the actual answer (in absolute value), among three classes of self-estimated capacities*

In the previous graph, AP stands for “the participants estimates that he posses absolute pitch recognition”, RP for “the participants estimates that he posses relative pitch recognition” and none for none of the previous options.

To understand better these results and for a deeper study, these results are now sorted as a function of what are thought to be interesting parameters of investigation.

## b. Influence of the instrument acoustic category

The statistical representation of the computed mean (over all series) absolute difference between the presented tones and the participants answers for each instrument acoustic category in shown in the following figure.

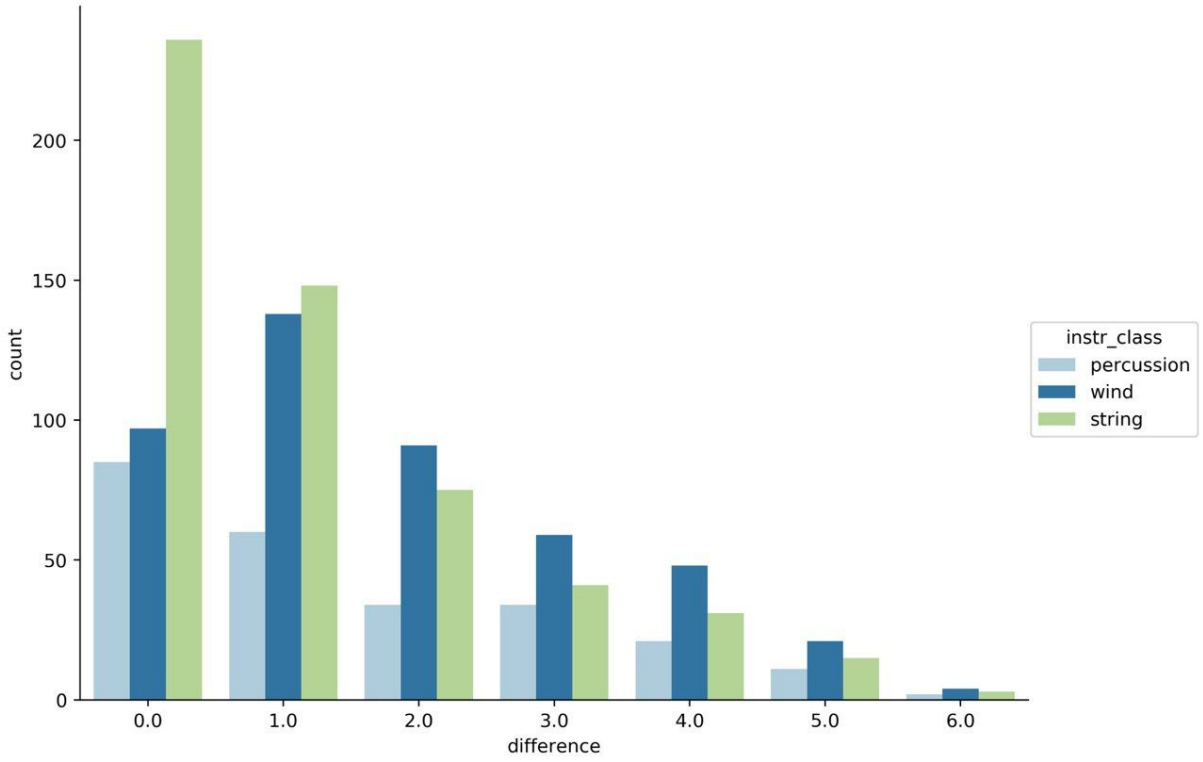



*Fig 3 : counts of responses given, by distance from the actual answer in terms of pitch, separated among classes of instruments.*

From the previous figure, one can clearly see that musicians playing certain categories of instrument yields better tone recognition capabilities than others. As expected, string instruments players perform are the most accurate ones, with an average distance of  1,16 semitones, followed by wind instruments, with an average distance of 1,49 semitones and percussion instrument players, with an average distance of 1,56 semitones.

One possible interpretation of the previous results is the following: as most of string players are able to control in a continuous fashion the frequency of the produced sound and - see the following paragraph - as a majorite (61%) of strings players questioned are fretless strings players, one can imagine that these musicians rely a lot on hearing and by extension to note qualification (quality of tuning, note recognition) for their playing. Wind instruments can also on a smaller extent control certain parameters when producing a note, usually by changing the excitation produced by the mouth. On the other hand, percussion players can be thought to  mostly interact with the instrument as a visual tool for production of the wanted tone, without need for posterior recognition of the note or control on the tuning of the note. This can explain their lowest result in the note recognition test, as they would have lower advantage in developing a strong pitch recognition capability on average.

## c. Influence of the instrument note quantification mode

To investigate a bit further the prior results with additionals intuitive categorical differentiation, the counts of the difference for categories of instruments that have certain features such as frets, pistons, keys (quantified : piano, trumpet, guitar...) or fretless (not quantified : double bass, violin, trombone...)  none of them are shown in the following figure.

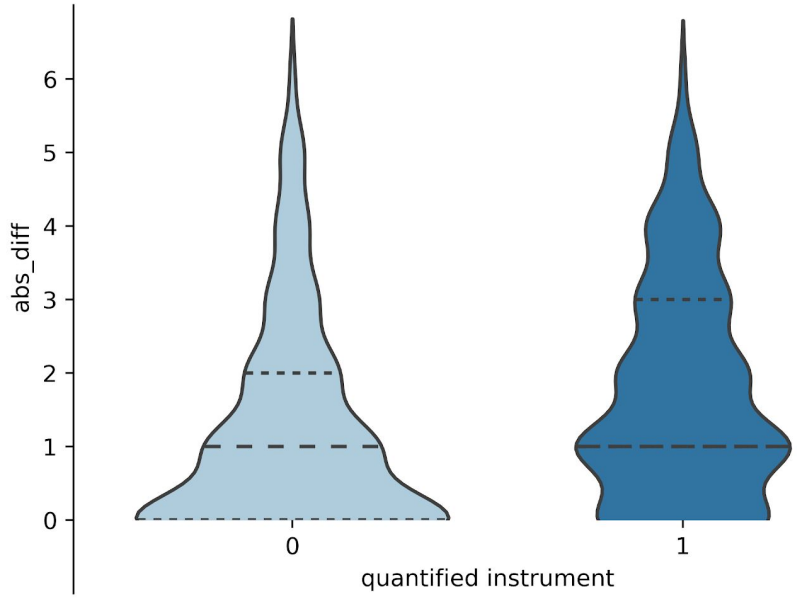



*Fig 4 : Distribution of the distance to the right answer, for quantified (1) or not quantified (0) instruments*

From the previous figure, one can clearly see that once again musicians playing certain categories of instrument yields better tone recognition capabilities than others. This time, “not quantified” instruments players perform are the most accurate ones, with an average distance of 1,13 semitones, and “quantified” instrument players, with an average distance of 1,48 semitones.

Once again, a possible interpretation of these results relies on the understanding of the instrument as an interface for the musician. Fretless instruments’ players indeed perform better than fretted instruments’ player due to the greater advantage in terms of precision of tune for an accurate note recognition capability.

To study this point even further, one would have to study the musical instrument as an interface as previously suggested and extract - possibly using an EGG setup - the representations of music that rely on this interface and finally explain the link in a cognitive perspective between pitch recognition capability and the internal, psychological, personal and  latent music representation.

# d. Influence of the musical practice context

## i. Influence of the usual collective dimension

The mean difference count distribution as a function of several types of usual playing contexts is shown on the following figure.

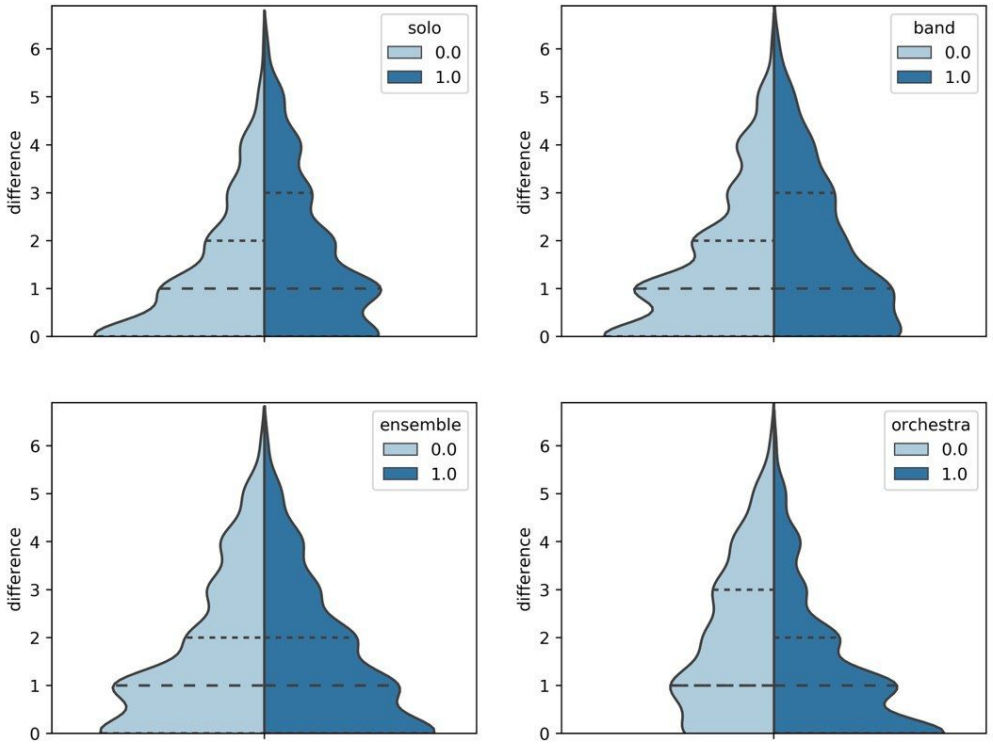



*Fig 5 : Distribution of the distance to the right answer, for several habits of music practice*

It appears that musicians who play in ensembles or even orchestras perform better than other musicians who usually play solo or in small bands. This result can be interpreted as the need for recognition of other musicians' production in ensembles and orchestras, along with the possible need for adjusted tuning with respect to other musicians. Interaction during the instrumental practice therefore seems to be an important parameter that affects the capability of pitch recognition.

## ii. Influence of the usual playing musical style

The difference distribution as a function of several musical styles that the musicians usually play is shown on the following figure.

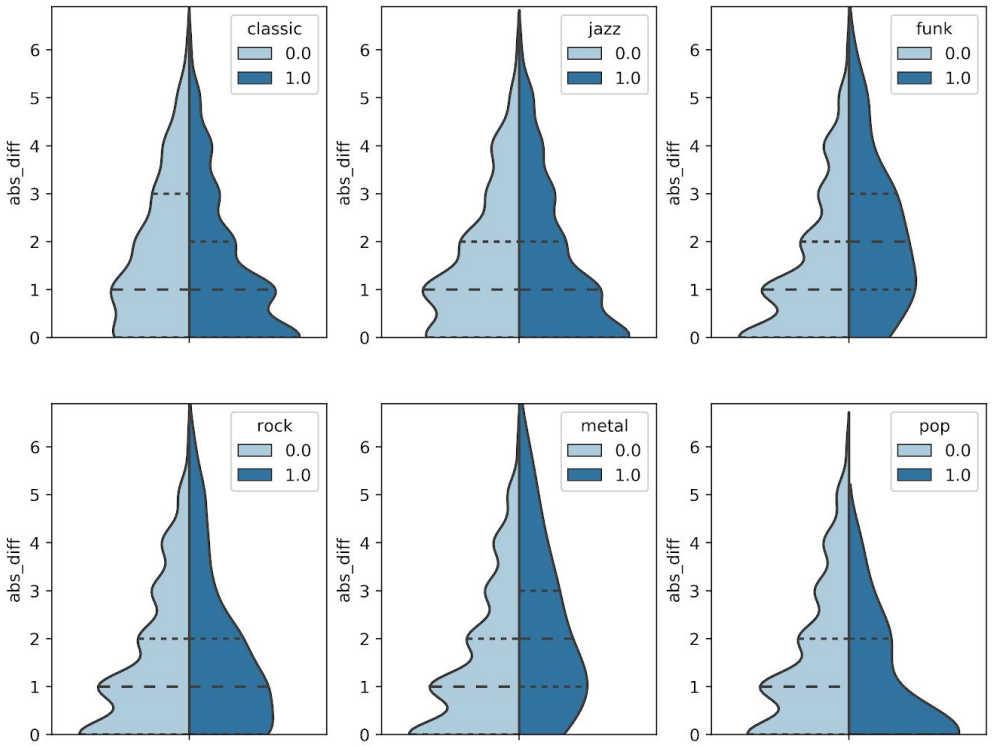



*Fig 6 : Distribution of the distance to the right answer, for several genres usually played by the participants when practicing*

One can clearly see that musicians who play classical music and jazz performs better than those who don't, at the opposite of metal, rock or funk players. It is unclear whether there is a correlation with previous results, as classical musicians for instance could possibly have more musical experience (among the population of musicians at EPFL), play in bigger ensembles than what is expected in other musical styles, or simply because styles like funk rarely involve fretless string players that are thought to perform better because of the instrument hearing requirements.

For further investigations, a more rigorous categorisation that would rely on musical features for instance would have to be considered, along with a correlation study to the previous results.
A possible interpretation for this results would be that for specific styles such as jazz and classic music, emphasis is given on techniques that involve note recognition capabilities such as improvisation or as previously mentioned, tuning adjustment in the case of classical music.

# 5. Conclusion

By looking at the data gathered with the test and form from 36 participants, several factors can be found among participants that have similar hearing capacities. According to the class of instrument, it was observed that string instrument players were the ones who got the lowest mean difference between the given answer and the right answer.
This observation was refined by ordering the instruments not per class but per mean of quantification : it was observed that musicians who could play a non-quantified (e.g. fretless) instrument performed better than the others.
To the question whether the musical context could show differences in the performances in the test : it was observed that musicians who play in ensembles perform better than musicians who play solo or in small bands, and second we observed that musicians who usually play jazz and classical music had developed better hearing capacities.

For future it would be interesting to correlate these factors, trying to see if musicians who play ensembles and classical perform even better for example.