INFLUENCE OF INSTRUMENTAL PRACTICE ON ABSOLUTE NOTE RECOGNITION: A STUDY ON MUSICIANS AT EPFL

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ABSTRACT

Note recognition abilities constitute a central aspect for musicians and psychologists, as it provides both an understanding of the musical material and its emergence context. Altough earlier studies yield key points for the emergence and sustain of absolute pitch and relative pitch hearing: age of first music studies, timbre of the stimuli, presence of family members with absolute pitch abilities and other environmental factors. However, the influence of the instrumental practice on note recognition abilities is not well studied yet. This paper presents a study on note recognition abilities among musicians from EPFL and proposes some interpretations of the results that are linked to instrumental practice features.

1. INTRODUCTION

The understanding of note recognition abilities constitutes a central research problem for psychology and cognitive musicology. Several types of note recognition abilities have been identified, for instance under the names of absolute (or perfect) pitch or relative pitch. Some important points have already been found regarding the contexts among which these abilities are most likely to appear and the parameters that influence these abilities, such as the age of first music studies [2], the exposure to certain languages [7] or familiarity to the presented stimuli [1].

Furthermore, while a musician learns to play a instrument, she usually becomes more and more efficient at using the instrument. During the learning process, the musician would build several internal representations that links the musical content to the interface manipulation. One would think that these representations are linked to the instrument itself as an interface, so that it shapes the musical material that the musician produces in different ways, depending on certain features of the instrument, such as whether the instrument can produce a quantized set of notes or not or whether the instrument is tuned or untuned. Moreover, these representations would also be linked to the context in which the musician uses its instrument.

As the absolute pitch recognition ability can be partly thought to rely on learned musical representations, empirical observations suggest that this ability can appear and be expressed differently among musicians depending on their instruments.

The question that the present paper addresses in a limited extent is the following: how does the instrumental practice influence the expression of absolute pitch recognition abilities among musicians ?

The intuition behind this question relies on the same understanding of the music instrument as an interface between the musicians ideas and the musical content. From this conceptualization, 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 visualization 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, 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 seems 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. It is likely that musicians who improvise put greater attention to the content of their production, such as the notes themselves, and try to conceive it prior to the production, giving much more weight to capabilities such as absolute pitch hearing than other musician who would read scores.

2. METHOD

The goal of the experiment was to evaluate the ability of musicians, among EPFL and UNIL students, to identify pitches by hearing without a reference note; and to try to link their performance with their instrumental practice and studies.

2.1 Participants

36 participants were gathered, aged from 18 to 30 years old (mean = 22.6 years old), with and average length of practice of 15.5 years. We chose *a priori* to classify the 36 musicians among the following categories: there were 5 tuned percussions players (piano players), 2 untuned percussion players (drummers), 8 brass wind players (trumpet, trombone, horn), 5 wood wind players (saxophone, clarinet, oboe), 10 fretless string instruments players (violin, alto, cello) and 6 fretted string intruments players (guitarists). This arbitrary classification follows our intuition of what could be some interesting features of the instruments with respect to the development and expression of absolute pitch recognition abilities. The Figure 1 shows the distribution of the self estimated age of first music studies among all the participants.

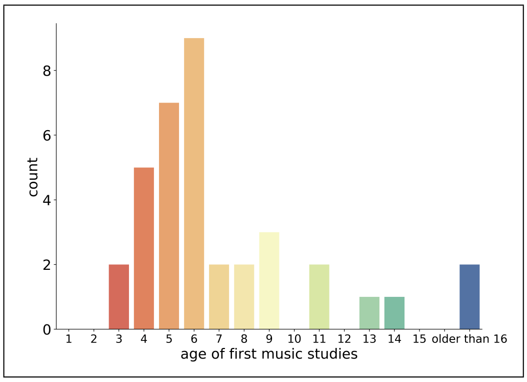

Figure 1. Distribution of the ages of first music studies

2.2 Data collection

The collected data consisted of both results from an individual questionnaire on the participants musical habits, background and self-evaluation and was followed by an auditive test. The data was collected by hand (both during the questionnaire and the hearing test) by one of the supervisors of the study.

2.3 Audio stimuli

The participants were hearing 3 series of 12 tones each. Each tone lasted one second and two consecutive tones were separated by a 8-second gap. The 3 series had each a different timbre, the first one being a pure tone, the second one a piano timbre, and the third one depending on the instrument timbre the participant was familiar with : a wurlitzer timbre for percussion players, saxophone for wood wind players, trumpet for brass wind players, violin for fretless string players and guitar for guitarists. The pitches were randomly played in a range of 3 octaves, separated by more than one octave.

2.4 Procedure

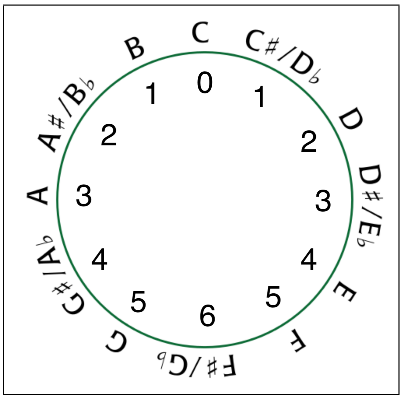

Figure 2. Lee distance for a C as reference pitch.

The difference - or error - in semitones between the played pitch and the answer given by the participant is computed according to the Lee distance, a 0 distance being the exact answer (cf. Figure 2) and 6 the distance of the note a tritone higher than the presented tone. The participants were only asked to tell which pitch they were hearing without specifying the octave. If the participant was used to play with a transposed scale (for example in B flat for saxophonists), she could give her answers with respect to this scale, and then they were transposed back for computation.

3. RESULTS

The total distribution of the errors (the distance from the participant answer to the presented pitch) on all the tests is shown on Figure 3. The mean error is of 1.47 semitones with a standard deviation of 1.48.

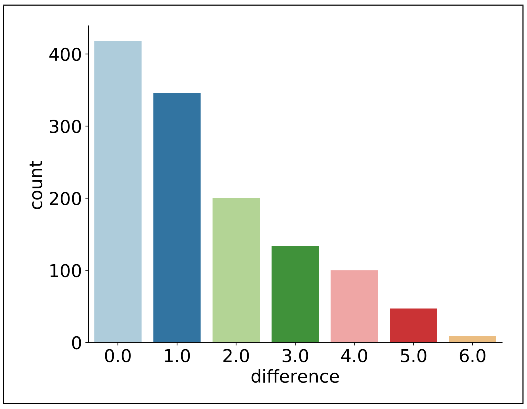

Figure 3. Total distribution of error

The distribution of the errors for each acoustic category of instrument is shown on Figure 4. The mean error is 1.79 semitones ($\sigma = 1.49$) for winds players, 1.54 semitones ($\sigma = 1.56$) for percussions players and a 1.16 for strings players ($\sigma = 1.39$).

Among string instrument players, the error as a function of the presence of quantification features (fretted or fretless strings players, $n_{fretted} = 6$, $n_{fretless} = 10$) is

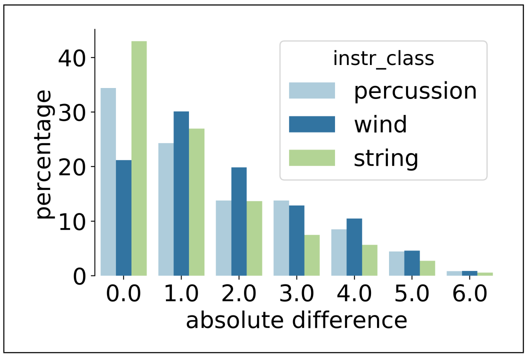

Figure 4. Distribution of error per acoustic class of instrument

plotted on Figure 5. The mean error was of 0.91 semitones for fretless string instruments players ($\sigma = 1.23$) and of 1.60 semitones for fretted string instruments players ($\sigma = 1.46$). A two sample t-test, with a significance level $\alpha = 0.01$, comparing the absolute value of the error for the fretless string instrument players and for the fretted string instrument players, gave a t-value of $t = -1.025$. As $t_{5,0.01} = 4.032$, we must accept the null hypothesis that the two samples groups have different performances to the test.

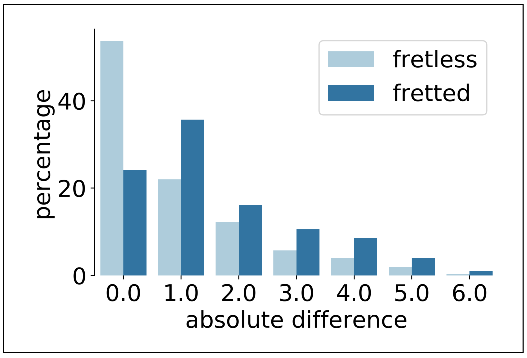

Figure 5. Distribution of the error among string instrument players

Percussions are then split into tuned percussions (piano, $n_{tuned} = 5$) and untuned percussions (drums, $n_{untuned} = 2$). The distribution of the error among percussionists according to this categorization is shown on figure 6. The mean error was of 1,17 semitones for untuned percussions players ($\sigma = 1.64$) and of 1.70 semitones for tuned percussions players ($\sigma = 1.50$). A two sample t-test, comparing the absolute value of the error for the untuned percussion players and for the tuned percussion players, gave a t-value of $t = 0.034$. As $t_{2,0.01} = 9.925$, we must accept the null hypothesis that the two samples groups have different performances to the test.

The Figure 9 shows the error distribution as a function of the self-estimated abilities of the participants. Note that the interpolation in the y-axis between integers is only showed as a visual help, as the error is a discrete measure.

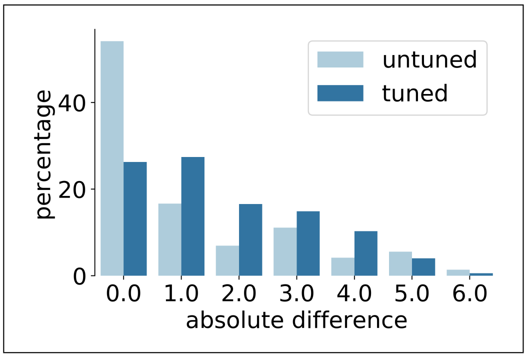

Figure 6. Distribution of the error among for tuned percussions players versus untuned percussions players

The Figure 7 shows the distribution of errors as a function of usual ensemble type playing context: solo, band (2-8 musicians), ensemble (10-25 musicians) or orchestra.

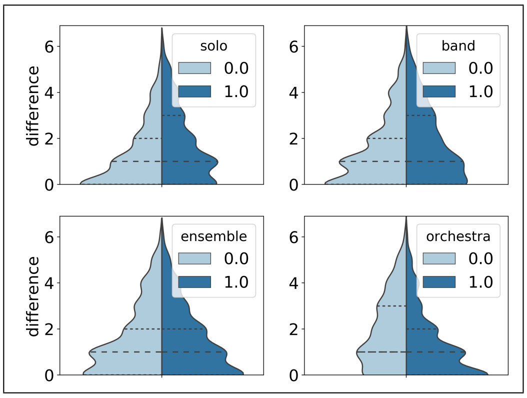

Figure 7. Distribution of errors as a function of the usual ensemble type playing context

Finally, the Figure 8 shows the distribution of errors as a function of the usual played music style.

4. DISCUSSION

Several assumptions and hypothesis are made in this study. First, we assumed that musicians around EPFL campus are familiar with the modern, Western untempered chromatic scale and that the names of the chromas can both be given using the flat (♭) annotation or sharp (♯) annotation without any difference. 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 such that measures of distances from their answers to the presented tones lie between 0 and 6 as in a cyclic alphabet. We also assumed that the methodology proposed is indeed able to give a measure of the phenomena that represent local, context independent tone recognition without measuring any artifact of relative, context-sensitive pitch recognition. Finally, we assumed that the given 8 second window for the participant to give her answer allowed only people with direct recognition systems such as absolute pitch recognition

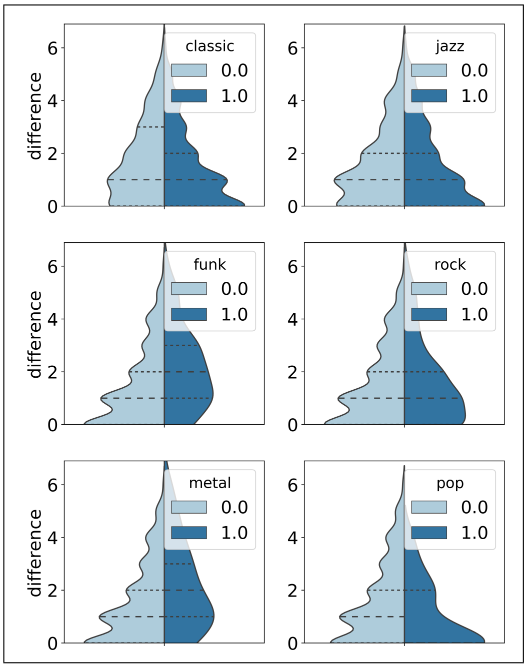

Figure 8. Distribution of errors as a function of the usual played music style

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 this method.

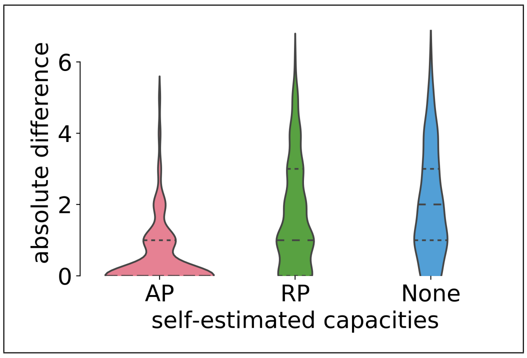

Figure 9. Distribution of errors as a function of self estimated abilities

As a consistency check, we observe that the self-evaluations of the participants matches our results (Figure 9), so that people who estimated they do not have absolute pitch abilities performed worse than people who estimated they have absolute pitch abilities.

The total distribution of the errors (Figure 3) shows that on average, the participants performed much better than chance, which would be given by a uniform distribution and an overall mean error of 3. One can clearly observe a step between the count of 2 semitone difference and the count of 1 semitone difference, that we can interpret as the fact that most of the 0 or 1 semitone distance errors are due to participants having absolute recognition abilities and the rest being mostly given by participants having less precise or no absolute pitch abilities. It is important to note that some participants had absolute pitch recognition abilities on a different categorization than the 12 chromas categorization: they would for instance not mention flats and sharps when there were alterations, therefore always give a note distant of 0 or 1 semitone from the reference pitch. This is explained by the idea that absolute pitch correspond to an internal mapping of frequencies to certain names of notes, that can be more or less precise depending on the contexts of learning that led to the absolute pitch recognition abilities. As it is often common that notes with 1 semitone distances have names that start the same but with some sharp of flat addition, it may be the case that the internal mapping of these musicians did not take into account the alterations at all. It remains unexplained why there is a decrease in the counts of errors from 2 to 5 semitones: if the participants would answer by chance, the distribution for these errors would be uniform and the number of errors of 6 chromas would be half the number of counts of errors of 2, 3, 4 and semitones. One explanation for this is that musicians still have some unconscious intuition of where the presented not lies in the octave and therefore are able to give a more accurate answer than a random answer. An other explanation is, for certain instruments such as string or wind instruments, that some notes are easier to perform on these instruments, such as open strings notes for strings that are played more often and also can serve as reference when tuning or during the playing. Some participants such as guitarists recognized those notes accurately and were performing poorly on other notes, sometimes unconsciously.

When comparing the results of several classes of instruments (Figure 4), we observe clear differences for the amount of exact answers and the same tendencies for increasing errors but with less magnitude. It was expected that the string instrument players would perform better, following our assumptions, which is indeed the case, surprisingly followed by percussionists and wind instrument players. One should however note that the number of percussionists is not sufficient for statistical relevancy and therefore should be considered with care. Indeed the results of the two t-tests may be unrelevant because of the lack of data : there were only 2 untuned percussion players and only 6 fretted string players. At the difference of percussionists and strings instruments players, wind instruments players answers more often with an error of one chroma than exacts answers. It can be explained, in addition with the categorization of natural and altered notes as explained previously, by the unconscious transposition that some participants could have done, even though they thought they were answering in a non-transposed scale.

On Figure 5, the same pattern appears for fretted (quantized) instruments players results, although it is unclear what is the explanation for its appearing. As expected in our prior intuition of the phenomena, we observe that fretless string instrument players perform better than fretted instrument players.

On Figure 6, we observe that untuned percussions players perform much better than tuned percussions players, in contradiction with our prior intuition. It is however the smallest set of values in the whole study (only 2 untuned percussions players are tested) and the results are therefore statistically inconsistant, which can explain the contradiction with our predictions. A test on more musicians could confirm or infirm this result.

To study these points 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.

The Figure 7 shows that participants yields better absolute pitch abilities when usually playing in big ensembles. Note that the audio test was however not performed in these precise contexts. 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.

One can clearly see on Figure 8 that musicians who play classical music and jazz performs better than those who dont, at the opposite of metal, rock or funk music players.

Although it is not clear whether these features are responsible for the emergence and expression of absolute pitch abilities or whether it is that people who ave absolute pitch abilities choose their instrumental practice because of their abilities, the number of years in which the participants practiced their instruments and more precisely the age at which most of them started playing their instrument lead us to think that it is improbable that the participants chose their instruments according to these abilities. However, we can not make the same observation and hypothesis with respect to the usual style of music and ensemble that the participants play with, as we have no indicator of the origin of these choices and whether they were *a priori* linked to absolute pitch recognition abilities. For instance, classical musicians 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 privilege certain styles as others, for instance funk rarely involve fretless string players that are thought to perform better because of the instrument hearing requirements.

For further investigations, a more rigorous categorization that would rely on musical features for instance would have to be performed along with a correlation study between the investigated features of the instruments.

5. CONCLUSION

The importance of instrumental practices in the expression of musical features and abilities is yet not understood, mostly their influence on absolute pitch recognition abilities. Our test and results show good indicators that these instrumental practice could play a role in the expression and emergence of absolute pitch recognition abilities. Among musicians of EPFL and UNIL, we investigated some features that we thought would influence the absolute pitch recognition abilities using a questionnaire and an audio test and pointed out the relevancy of some of them such as the quantification of the instrument.

Although some questions that we discussed still need further investigation and bigger datasets to be statistically relevant, we provided a first step for understanding and studying the influence of instrumental practices on absolute pitch recognition abilities, that could be extended to many more fields of investigations such as the expression of certain idioms in improvisation contexts, complexity and diversity of the repertoire, rhythmic precision or singing abilities, as functions of the instrumental practices.

6. REFERENCES

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