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Marimba, mallet and mind – enhancing the marimba sound by Ki-aikido approach

Henrik Knarborg Larsen[a], Ole Adrian Heggli[b] and Bjørn Petersen[a,b]

[a]The Royal Academy of Music, Aarhus/Aalborg, Denmark; [b]Department of Clinical Medicine, Center for Music in the Brain, Aarhus University & The Royal Academy of Music, Aarhus/Aalborg, Denmark

ABSTRACT
This study highlights the potential benefits of applying physico-mental strategies from the Japanese martial art Ki-aikido in the general approach to teaching and playing percussion instruments. Two groups of percussion students played an exercise on marimba before and after either a Ki-aikido or a control instruction. Between-group Fourier analyses were robust and showed a significant effect of the Ki-aikido intervention, indicated by a change in the harmonic distribution in the instrument's timbre. By contrast, subjective ratings by marimba experts were less consistent and showed no effect of the intervention on any parameter. More research into the field is encouraged.

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Marimba; Ki-aikido; timbre; sound quality; spectral analysis

Introduction

The classical Western marimba is a percussion instrument which spans five octaves of bars, arranged in a chromatic configuration, similar to the keys on the piano. The bars are made of wood, often Rosewood, which contributes to the instrument's characteristic expressive sound. A peculiarity of the marimba, in contrast to many other instruments, is that the overtones are not necessarily harmonically distributed. This is a result of the physics at play when a mallet transfers energy to a rectangular bar, and in theory leads to an ambiguous sensation of pitch particularly in the lower frequencies. To counteract this effect, it is common to tune the marimba bars by constructing arches under the bars, thus enhancing the harmonic two octaves above the fundamental (the fourth harmonic) and the harmonic three octaves plus a major third above the fundamental (the tenth harmonic). As a result, the marimba will tend to produce a soft, warm and mellow timbre as opposed to e.g. the xylophone which tends to sound distinct and sharp (Bork, Chaigne, Trebuchet, Kosfelder, & Pillot, 1999; Yamaha corp., 2018). It is, however, possible to vary the timbre of the marimba by use of different playing techniques, thereby modifying the balance of the harmonics (Cheung, 2011). For example, the location (i.e. distance from the centre) at which the bars are struck and the strength and the precision with which the bars are struck are factors that may influence the sound. These techniques modify which of the harmonics become dominating, and hence changes the timbre of the instrument.

The technique and expression of sound on marimba has developed intensively during the last 50 years (Cheung, 2011; Hartenberger, 2016; Stevens, 1979; Zeltsman, 2003), and the ability to create chords and polyphonic music by use of 4-mallet technique has initiated the creation of a modern marimba repertoire with pieces that demand an extraordinary control of the instrument (Bernat, 2016). Because of the marimba's size (2,5 × 1 m), the marimba player must constantly strive for the optimal position and body posture, when performing (Lin et al., 2017). In addition, playing the marimba involves minimal direct contact with the sounding object; the instrument is played with mallets and the mallets touch the instrument very briefly. Thus, the precise imagination of sound and control of the physical actions needed, accentuate the importance of establishing a strong connection to the instrument – a connection that encompasses the most precise unification of mind and body.

As a general trend, many music performers and educators have taken up physico-mental methods, i.e. methods that draw on the unification of mind and body, to facilitate the development of motor skills and improve musical learning. Mental practice, for instance, including visual imagery has proven efficient as a way to supplement physical practice in the process of learning new pieces (Bernardi, Schories, Jabusch, Colombo, & Altenmüller, 2013; Dennis, 1985). Other examples are Eastern traditions such as tai chi and yoga and Western methods such as the Alexander Technique (Albert, 2016;

CONTACT Henrik Knarborg Larsen mail@henriklarsen.org The Royal Academy of Music, Aarhus/Aalborg, Denmark

Cheung, 2011). Recently, techniques from the Japanese martial art Ki-aikido have emerged as a promising supplementary element in the education of both musicians (Greene, 2001, 2013), dancers and actors (e.g. as part of Yehudi Menuhin's music teaching programme) (Makiyama, 2016). In these techniques, a direct physical response to specific mental pictures are explored through concrete physical tests.

Aikido literally means 'The Way of Harmony' and combined with the physical techniques used for defense, the aim is to transform internal and external threats into a new state of awareness. Ki-aikido focuses on the process of transforming a person's aggressive energy in a non-aggressive way through physico-mental exercises. This incorporates a method of learning to unify mind and body, the thesis being that the one responding to the aggressive energy will be faster than the aggressor (Yoshigasaki, 2015). To help master these techniques, special Ki-tests have been developed that strive to reduce the separation between body and mind that has been part of Western philosophy since Descartes introduced the distinction between res cogitans and res extensa (Ruglioni, 2008). The methods of the Ki-test introduce a step by step method of using a physical test done by a partner to deliberately refine attention, determination and balance.

The most common test examines the stability of the body by applying a light pressure on the chest bone from the hand of a partner. If the body and mind are stable, the pressure will be felt in the foot soles. If not, it will be easy to destabilise the person, either by moving the upper torso, or, if the person attempts to be strong by tightening the muscles, by changing the balance so the person falls backwards. There are different ways to improve the result of the test, gradually developed through the Ki-aikido training. The simplest is to stand on your toes and slowly put the feet back on the floor. For most people, this will change the mental focus from an attempt to pass the test to a perception of the whole body, and thus improve the results. The increased unification of mind and body achieved through this test may generalise to other domains, e.g. music where it might help performers optimise their performance (Makiyama, 2016).

For many marimba learners, the challenge is to establish a harmonious connection through the body and mallet and thereby enable a rebound from the instrument that lets the bar resonate freely with a warm and open sound. Essential for the performance of this is a grip that ensures a precise movement of the mallets without tightening the muscles in a way that makes the motion of the wrist slower. To be able to control this grip, the student may have to change his or her understanding of a 'powerful' grip. For this purpose, 'the good handshake' Ki-test may be helpful and finely illustrate how Ki-aikido ideas can be converted to percussion. If a handshake is too hard, using pressure to hold the other hand, you can, contrary to our expectation, escape very easily. If, however, you use the gentle approach of letting the fingers grow around the opponent's hand, imagining the 'hands being glued together', the grip gets much stronger, using attention instead of physical power.

The application of methods involving mental approaches in the training of musicians at music academies is a relatively new area with much potential for further research (Williamon, 2004). While some studies have investigated mental practice and development of motor skills, few studies have examined the potential beneficial effects of physico-mental approaches on the production of timbre. With this study, we aimed to test for the first time the hypothesis that a specific Ki-aikido physico-mental exercise may significantly improve the quality of the sound from the marimba. To investigate the validity of the hypothesis, we recruited marimba students from three music academies and recorded their performance of a simple exercise, following either a traditional instruction or 'the good handshake' – exercise. To analyse the data, we applied two different methodological approaches, an objective method based on spectrum analysis and a subjective method using expert ratings. If successful, we presumed that the results could inspire performing musicians and music teachers within a range of instruments to combine physical and mental approach by including techniques from martial art forms in their work.

Methods

Participants

To test our hypothesis, we recruited 36 music academy percussion students, of whom 12 were students at Juilliard School of Music, USA, 12 at Conservatorium van Amsterdam, Holland and 12 at Tampere School of Music, USA. The players agreed to take part in the experiment and were randomly assigned to either the experimental group or the control group with an equal number of 18 in each group. Sessions were held during Master Class visits payed by the first author. None of the students were familiar with Ki-aikido and the years of experience with marimba and 4-mallet technique was very similar in the two groups (mean experience $\sim$7 years; range 4–13 years for each group. 50% of students were on a BA programme, 50% on MA programme).

In the experiment, the participants were asked to play using a specific set of mallets (four Resta Jean Geoffrey Orange model with marble handles) and were given time for adjusting instrument height to their needs and getting accustomed to the mallets. To ensure consistency, they were asked to strike the bars at particular points, as indicated by white arrows (Figure 1).

All players were then asked to play a short musical exercise in C-major twice (see Figure 2), before and after a short instruction. The players in the experimental group were introduced to three different types of handshakes: a weak, a much too forceful and the 'good handshake' in which they were asked to 'imagine the hands being glued together and the fingers growing around each other' (see the Appendix for instruction details). Subsequently, they were asked to repeat the exercise with this idea in mind, when holding the mallets. Despite the unusual nature of the instruction, the participants could easily follow it which was confirmed by an observed stronger grip when approaching the last part of the exercise. Furthermore, all the sessions were recorded on video, by which we were able to review the students' reaction. No students seemed to lack understanding of the exercise, raised questions or complaints.

The players in the control group received a standard master class instruction in which they were asked to play the exercise 'focusing on the sound and playing with as open and warm a sound as possible'. As opposed to the Ki-aikido instruction which focuses on the internal representation of performance movements, the standard instruction has a more common focus towards outcomes and tone quality. The requested change will be familiar to most marimba students and with their level of expertise the control participants would all have a clear idea of how to fulfil the requirement. To ensure experimental consistency, all information was given from a written manuscript (see the Appendix).

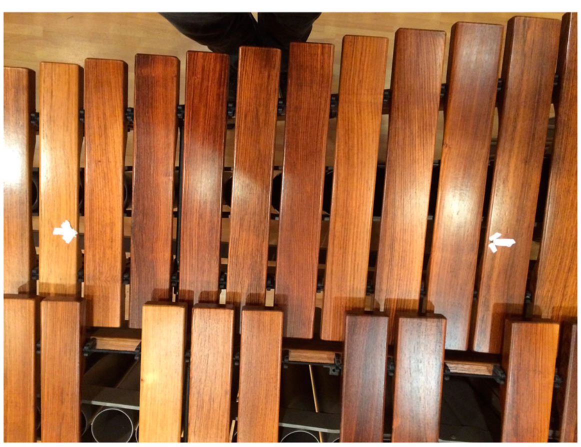

Figure 1. The marimba shown from above. White arrows indicate the point at which participants were required to strike the bars.

Recordings

Each session was recorded in high quality uncompressed digital audio with a Zoom H6 recorder and two Neumann KM184 microphones placed as an ORTF-pair 1 m away from and 1.5 m above the instrument. Similarly, all sessions were video-recorded as a backup as well as for having the option of inspecting more closely any outlying results.

To create sound files for subsequent evaluation and analysis, all recordings were edited in Logic Pro 10.3.3 (Apple Inc.) and saved in wave-file format at 24-bit resolution and 44.1 kHz sample rate. The process yielded 72 samples, 36 representing pre-intervention and 36 representing post-intervention.

Triangulation

To examine the potential effect of the physico-mental intervention, we chose a triangulation approach (Bogdan & Biklen, 2006; O'Donoghue & Punch, 2003), employing both objective and subjective measures. For the objective measures, we used the fast Fourier Transform (FFT) algorithm to inspect the energy of three prominent partials across all samples. If any partials exhibited stronger or weaker energy between groups, that would indicate an effect. For the subjective measures, we recruited a group of internationally acclaimed percussion experts and asked them to rate the quality of the sound from the marimba on three key parameters: resonance, overtones and attack.

To ensure that the subjective analysis had a manageable completion time ($\sim$ 1 hr), we cut the number of recordings to a total of 24. This was done by selecting eight participants from each institution (4 exp. + 4 ctrl.) by alphabetical order of surname. Subsequently, the resulting two groups were matched on gender, age and 4-mallet experience by replacements from the pool of

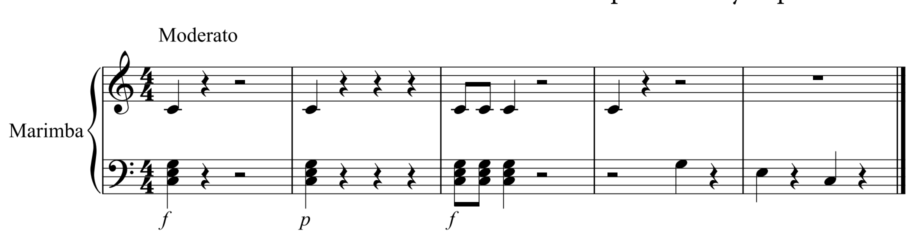

Figure 2. The exercise played by all participants before and after either a standard instruction or a Ki-aikido instruction.

residual participants. The same pool of recordings went into both the objective and the subjective analyses.

Objective analysis

As a general rule of thumb, sounds that may be described as 'warm' tend to have energy distributed towards the lower harmonics, whereas 'shrill', 'sharp', and 'bright' sounds usually contain more energy in the higher harmonics (McAdams, Winsberg, Donnadieu, De Soete, & Krimphoff, 1995). While this simplification offers a general approach to describing sounds dependent on their harmonic content, the distribution of the harmonics plays a crucial role. For instance, a sound containing both odd and even harmonics such as the sawtooth wave is often perceived as shriller and sharper than for instance the square wave containing only odd harmonics. Nonetheless, even though the link between harmonic distribution and subjective perception is still being explored, it offers a great approach to quantifying timbre (Risset & Wessel, 1982).

Our presumption is that if the third and fourth harmonic becomes more present in the sound of the marimba, the general experience of the sound will be perceived as harder. On the other hand, if the third and fourth harmonic is less present the sound will be perceived as softer and fuller. Furthermore, a more present third harmonic combined with the fourth harmonic will increase the presence of both odd and even harmonics – making the experience of the sound shriller.

Frequency analysis

To explore if the Ki-aikido intervention had an impact on the harmonic balance of the sound, we decided to measure three regions of interest (ROI) before and after the intervention. ROI 1 is centred around the third harmonic, ± 10 Hz, ROI 2 is centred around the fourth harmonic ± 10 Hz, and ROI 3 is centred around the tenth harmonic ± 15 Hz. The recordings from the different sessions were imported into MATLAB (MATLAB, 2016), where they underwent an FFT to compute the relative amplitude of the harmonics in the sound. These values were then exported from MATLAB to R (R Core Team, 2016). Here, we calculated the difference in relative amplitude between the post- and the pre-intervention recordings. The resulting value indicates a change in relative amplitude, with 0 signifying no change between pre- and post-intervention, a positive value indicating more energy in the region and a negative number representing less energy in the region. This way, we only consider a relative change, thereby alleviating most of the acoustical impact from different recording locations.

Subjective analysis

For the subjective analysis, we recruited ten of the most highly-skilled marimba soloists in the world (mean age 50.2 y; 4 females), who we supposed would be the best qualified to detect the subtle differences in the presented sound samples. Five of the experts represented a higher educational institution and five were either freelance or symphonic soloists. The experts all accepted the invitation and agreed to contribute with their assessments.

Since the experts lived in different parts of the world it was not possible to meet physically and collect the rating data in a controlled setting. Thus, we created a survey on the online platform Qualtrics (Qualtrics, Provo, UT) to which the experts got access through a link. Besides a professional interface, Qualtrics offers the possibility of measuring time spent on each question and number of mouse clicks.

The 24 items were presented in video file format in pre- and post-intervention pairs with clear indications of which of the two samples was presented. The order of samples was randomised, and the listener was blinded to the nature of the intervention and simply asked to provide his or her 'subjective expert assessment on whether the player's sound has improved in the second sample.'

Rating was done using the Likert-scale method, requiring the respondents to indicate their agreement with statements concerning the quality of three fundamental parameters of sound: resonance, overtones and attack. Following thorough scrutiny and piloting of the questionnaire, these parameters were chosen since they reflected the clearest references to the actual change of sound, which for all the samples were represented by very subtle details.

The respondents were instructed to listen not more than twice to the sample pairs and provide their assessments in the Likert-score field (see Figure 3). For familiarisation of the procedure, two example pairs were presented prior to the actual survey.

Parameters

The experts were asked to evaluate the parameters resonance, overtones and attack via specific statements (see Figure 3).

A fuller resonance

If the contact with the mallets are more precise it should be easier to control the sound. If the contact with the bar has the perfect duration for starting to vibrate with enough energy and if the mallets also move away in due time to not stop the vibrations of the bar, the resonance should be fuller.

Figure 3. The questionnaire interface presented to the experts for assessment. The sound was presented as a video with on screen signs indicating status of the sound ('before'/'after'). Five-point Likert-scale responses ranged from 'Strongly agree' to 'Strongly disagree' with statements regarding fuller resonance, clearer overtones and more synchronised attack. An open field for optional comments was available for each question.

Clearer overtones

If the mallet stays too long on the bar it could also create a node at the point of contact, creating false partials which could cause the overtones to be less clear.

A more synchronised attack

The timing of the attack between the 4 mallets held in two hands obviously relies on the ability to control them. Of course, most players at this level possess a good amount of control already, but synchronicity would also be likely to improve from the Ki-aikido instruction, especially in the soft nuances.

Results

Objective analysis of harmonic distribution

To control for any effect of location, we decided to perform a two-way MANOVA analysis with condition (control, experimental) and location (Amsterdam, Juilliard, Tampere) as independent variables and the difference in relative amplitude for ROI 1, ROI 2, and ROI 3 as the dependent variables. The multivariate result was significant for condition (Pillai's Trace = 0.402, F = 3.6, df = 3, $p = .037$, $\eta^2 = 0.40$), but no significant effect of location (Pillai's Trace = 0.243, F = 0.8, df = 6, $p = .588$, $\eta^2 = 0.12$) nor any interaction effect were found (Pillai's Trace = 0.226, F = 0.7, df = 6, $p = .634$, $\eta^2 = 0.11$). A Bonferroni-corrected post-hoc comparison revealed that condition had a significant effect on ROI 1 (df = 1, F = 10.24, $p = .015$) and on ROI 2 (df = 1, F = 7.34, $p = .043$). On average, the experimental group exhibited a significant lowering of relative amplitude in ROI 1 of −0.011, and −0.033 for ROI 2. While there appears to be a trend towards a corresponding increase in the higher harmonics, the statistical analysis does not confirm this. The strong effect size, in combination with no effect of location nor any interaction effect suggests that the results are systematically linked to the intervention (see Figure 4).

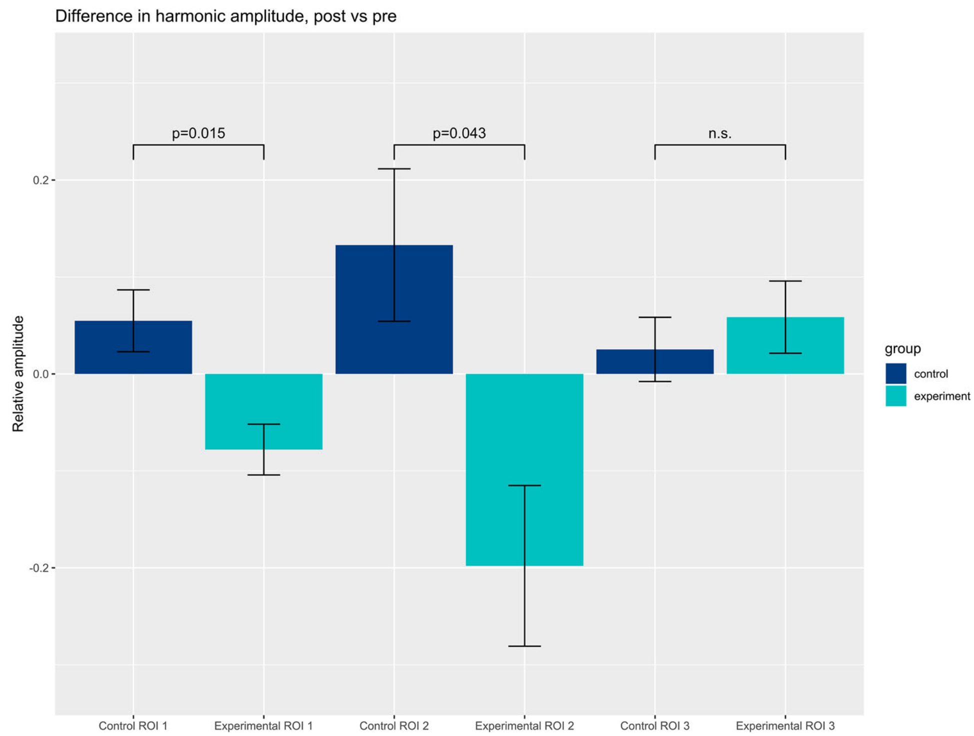

Figure 4. Mean difference in harmonic amplitude in the three regions of interest, for control and experimental group with standard error bars.

Within-chord balance analysis

Since the participants played a chord, we also wanted to check whether the intervention impacted the within-chord balance, i.e. whether they chose to put emphasis on certain notes in the chord. Following a similar procedure, we calculated the difference in relative amplitude between the fundamentals of the chord (C3, E3, G3, C4) in the post- vs. pre-recording. A two-way MANOVA with condition and location as independent variables, and the difference in relative amplitude for the fundamentals in the chord produced no significant effects. This indicates that the intervention did not impact the within-chord balance.

Expert ratings

Shapiro–Wilk tests of normality revealed that the expert ratings were not normally distributed ($p < .001$). Therefore, we applied the non-parametric Kruskal–Wallis 1-way ANOVA for testing the possible statistical effects of the intervention using the factor *Group* (Control, Experimental) as an independent variable. The analysis was run once for each of the dependent variables *Parameters* (Resonance, Overtones and Attack).

There was a main effect of Group on the parameter *attack* (H(1) $= 6.07$, $p = .014$, r $= .16$), suggesting that the experts assessed the improvement of the synchrony of the attack higher in the control condition than in the experimental condition. No statistically significant main effects of Group were found on the ratings of the parameters *resonance* (H(1) $= 2.84$, $p = .092$, r $= .11$) or *overtones* (H(1) $= 0.57$, $p = .565$, r $= .05$). Post-hoc analysis revealed that this main effect was driven by consistently higher improvement ratings for the control condition compared to the experimental condition specifically for the performance of the Juilliard students (H(1) $= 15.00$, $p < .001$, r $= .39$). A significantly higher rating of control group performance at Juilliard was also found for resonance (H(1) $= 7.74$, $p = .005$, r $= .28$). No statistically significant differences were observed for the samples obtained from the two other locations (see Figure 5).

Timing and clicks

The registered timing information showed an average response time for the complete survey of 29.8 min (SD 10.6; range 22.4–56.4). The mean single response completion time was 45 s (SD 23). The number of mouse clicks (not including clicks that activated video play and stop) showed a high variability (mean 4.1; SD 2.5; range 3–20).

Discussion

This study examined the effect of an applied physico-mental method from the Japanese martial art Ki-aikido on the quality of the sound produced by marimba players, performing the exact same short musical exercise. We

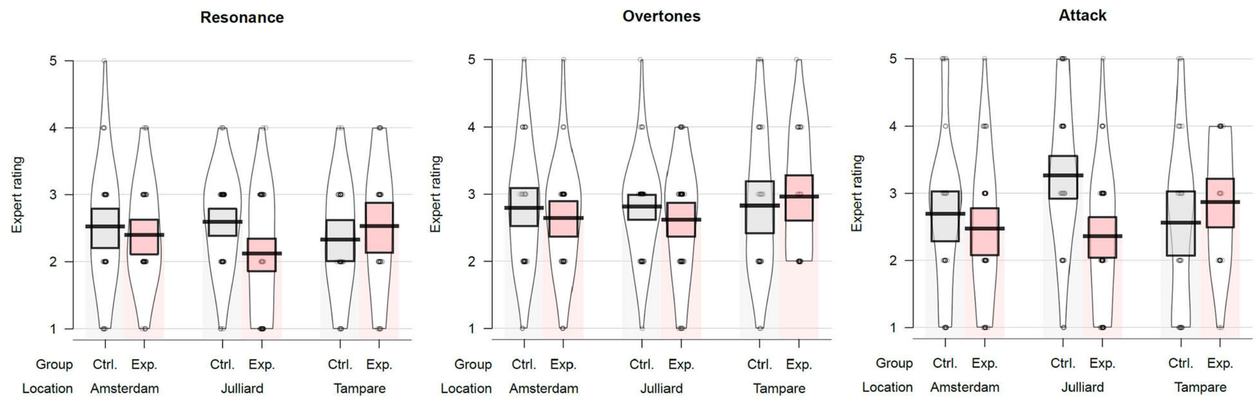

Figure 5. Pirate plots showing the results of the expert improvement ratings of the parameters Resonance, Overtones and Attack for control and experimental groups at the three locations.

assessed the difference between the sound produced by players who received either a standard instruction or a Ki-aikido instruction, using a triangulation method which involved objective analyses of changes in the relative amplitude of selected partials as well as subjective ratings by marimba experts.

Objective analysis

The frequency analysis showed a significant decrease in the amplitude of the third and fourth harmonic in the sound produced by the group of players who received the Ki-aikido instruction, whereas the sound produced by the players who were told to play with a warm and open sound exhibited no significant change. The observed change may be interpreted in different ways. First, a decrease in the amplitude of the third and fourth harmonics enhances the fundamental and creates less presence of both odd and even harmonics which may create an experience of a warmer sound. Second, the reduced level of the third and fourth harmonic provides space for projection of the 10th harmonic, which may be experienced as added clarity and openness to the sound.

It is well known that for instance expressivity in musical performance is linked to a change in timbre, and these changes are by necessity a result of the performer's mechanical interaction with the instrument (Barthet, Depalle, Kronland-Martinet, & Ystad, 2010; Chau & Horner, 2016). Since the Ki-aikido intervention specifically focuses on the grip of the mallets, the subsequent change in timbre is an expected result, reflecting the mental imagery and subsequent softer grip and optimised rebound provided by the exercise. While a detailed account of the physics resulting in the reduced amplitude of the third and fourth harmonic is beyond the scope of this paper, it is interesting to note the specificity of the intervention. Lower harmonics are often a key defining factor in the timbre of a sound, and recent research suggests that certain significant timbral features in instruments are critical for the conveyance of emotion in music (Chau, Wu, & Horner, 2015). The impact of the Ki-aikido instruction on the harmonic balance is therefore highly interesting as a tool for performers to adjust the timbrality of their instrument. This is further substantiated by the fact that even though the control group were specifically asked to repeat the exercise with 'as open and warm sound as you can', the objective analysis showed no significant change in the sound they produced.

Expert ratings

Effects

Contrary to our hypothesis, the expert ratings showed no effect of the Ki-aikido intervention on either of the three measured musical parameters and thus do not support the findings indicated by the objective analysis. By contrast, we saw an overall effect of the *control* intervention on the parameter *synchronised attack*. This result is intriguing, since the players were not instructed to play more synchronised; the control instruction only mentioned the parameters warm and open, both referring to sound quality. A possible explanation could be that the focus on sound quality made the students experience the chord more as a unity and therefore played the bars more synchronised. It is important to note, however, that the effect size is small and the variability high, indicating that other factors than the intervention may also have driven the result.

Institutional differences

As reported and illustrated in Figure 5, the ratings diverged according to educational affiliation. Control group students from Juilliard School of Music received significantly higher ratings for progress on the parameters attack and resonance, while control group students from the two other institutions received ratings that were marginally below or above those of the experimental groups (Figure 5). Since the participants were balanced regarding previous musical training and the three institutions all represent a high level of musical and educational expertise, there are no obvious explanations to this diversion. Several confounding factors may also have contributed to this finding. First, the number of performers from each academy (4 per group) was relatively small. Second, the acoustics of the recording venues were quite different, potentially influencing the judgment. Finally, the objective analyses did not support any differences linked to affiliations. In sum, we believe that the findings may not be too reliable and thus refrain from further interpretations.

Methodological considerations

Objective measurements

For inspection of spectral features of sounds, FFT is in general considered a robust and reliable method and although many other features of sound, particularly envelope (attack, sustain, decay, release), characterise the timbre of a sound, FFT was the natural choice in the present study. FFT has been applied in several studies involving musical timbre (Jensen, 1999; Sun, 2019; Thoret, Depalle, & McAdams, 2017) and recently the Music Information Retrieval (*MIR)Toolbox* has been introduced as an add-on to Matlab (Lartillot & Toiviainen, 2007). In addition to rhythmicity and intensity, MIRToolbox offers the opportunity to extract several features such as timbral characteristics, spectral flux, roughness and tonality from entire pieces of music by the application of FFT. *MIRToolbox* has formed the methodological foundation in several studies, including neuroscientific experiments investigating the link between salient features of music and brain activity (Alluri & Toiviainen, 2012; Alluri et al., 2012; Poikonen et al., 2016). While computational measurements such as FFT may offer insufficient information about the abstract and emotional aspects of music, they do provide consistent quantitative measures of sound. Thus, for the present study the approach seems both convincing and well suited.

Subjective measurements

By contrast, several factors may influence the credibility of the subjective assessment. First, the terminology used to describe the timbral parameters in the survey may have caused inconsistent conceptions among the experts, adding to the huge variability observed in the data set. Despite our efforts to select the most common terms, definitions of timbre are by nature subjective and sensitive to individual and personal interpretation. Furthermore, the task required from the experts (listening to the same exercise 48 times) holds the risk of ear fatigue and subsequent hampered ability to make precise assessments, making the results less reliable. Finally, the subjective ratings were – subjective. What one expert hears as an obvious improvement may be perceived completely different by another expert. As also illustrated in the plots, the range of agreement to the statements put forth in the survey covered the whole spectrum from 'strongly agree' to 'strongly disagree'.

This raises the question of whether the use of experts within the same field of profession and with strong individual preferences is a good idea. A recent study by Saitis (2011) seems to suggest that it may present a large risk of rating inconsistency. In their experiment, 13 violinists tested 10 different violins and ranked them subsequently, according to preference and five specific criteria. The authors reported significant disagreement between participants on all parameters but one, probably originating from 'large variations in the perception of different violin attributes'. In the present study, an alternative possibility would have been to recruit sound experts who may be less focused on the instrumental features and more focused on the spectral characteristics.

Limitations of the study

With this study, we strived to apply a research design that would meet the requirements of 'best scientific practice' with the ambition to create an unbiased and fair test of our hypothesis. Participants were randomly assigned to the type of intervention, subsequent groups were thoroughly matched, experts were blinded to the type of intervention involved, recordings met high-quality criteria and robust and strict standards were used in the statistical analyses. Nevertheless, the study contains several limitations. First, in the best-case scenario, all the experimental sessions should have been held in the same room with optimal acoustics, the same instrument and with a perfectly controlled recording set-up. Such standardisation would significantly have improved the basis on which both the subjective and the objective analyses were carried out. Second, the expert ratings should optimally have been performed under the exact same listening conditions including high-quality headphones and calibrated playback levels. Third, as indicated by the variance in survey response time and number of clicks, the online survey provided a platform that was under less experimental control than desired. Most pronounced with regard to the number of times samples could be played back. While the instruction was to listen once or twice (in itself too open), some may have listened more times, possibly changing their first spontaneous responses. In a more optimal setting, the experts should have performed their evaluations under similar circumstances, e.g. controlled by an experimenter.

The musical exercise was played with the same mallets for all participants to ensure consistency in the sound. Even though the participants had some time to get accustomed to the mallets, allowing the use of their favourite mallets might have positively influenced their ability to change the sound (marimba players use many different types of mallets). Furthermore, the mere knowledge that they were being recorded and part of a scientific experiment may have affected the participants' behaviour. Dubbed the 'Hawthorne effect', it is well-established that individuals may modify their behaviour in response to their awareness of being observed (Landsberger, 1958; Monahan & Fisher, 2010). In this case maybe even more so, because the experimenter was at the same time an authority within their professional field. The logistics, however, did not give way for an alternative solution, primarily due to considerations of time and place, but just as much because of the specificity of the Ki-aikido intervention. Furthermore, the circumstances were similar for all participants and should thus not represent any major importance for the results.

Conclusion

This study provides new data on the effect of a specific instruction used in Ki-aikido on the sound of the marimba. As indicated by spectrum analyses, the physico-mental awareness provided by the Ki-aikido instruction may significantly change the harmonic distribution in the instrument's timbre, thus providing room for a warmer, clearer and more open sound. The subjective analyses provided by marimba experts do not support the objective results and show an overall effect of the control instruction on the synchrony of the attack. Whereas the objective analysis constitutes a solid and consistent platform for measurements, the subjective approach is flawed by several inconsistencies and thus less reliable. The study highlights the potential of taking Ki-aikido strategies into consideration in the general approach to teaching as well as production of sound on percussion instruments In a wider perspective, however, there is a need for more research into the field.

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Appendix. Manuscript for experimental and control instructions

A.1 Experimental group

Play a little on the instrument with these mallets to feel comfortable with them. 2 min

Does the height of the instrument suit you? (make changes)

Play this little exercise, which consists of a C-major chord repeated 5 times as written. Please strike the bars where the arrows point.

Now I present for you a picture on how to feel the connection between the mallets and the hand. The analogy is the handshake where we make 3 different versions.

(1) the weak handshake
(2) the uncle handshake
(3) the good handshake

Now we try, and I explain (Weak handshake: With no energy) (Uncle handshake: Too much squeezing, like one of your mad uncles) (Good handshake: All the fingers (incl. the thumb) prolong and make as much contact with the other hand as possible. Imagine that our hands are glued together with the world's strongest glue.)

(Each time I show it first and then the student tries to do the same. I correct it if it is not done correctly)

Now we try how stable these handshakes are if we try to move our hand away.

First the weak handshake. (I move my hand away) and now you try– (the student moves away). So it is easy to move. This is like not having contact to the mallets when we play.

Then the uncle handshake: I try to move, and you hold my hand, so I can't move it . . . . And you try . . . So, it is possible to draw your hand towards you even though the other uses much force to prevent it. Using this kind of force to hold the mallets doesn't make the grip stronger.

Now we try the 'good handshake'. First you try to move . . . so I think of prolonging my fingers – like a plant growing around your hand – and that I am glued to the hand.

Was it easy to take your hand away?

Now you try to make the same good handshake and I will test if I can move away. Think of prolonging your fingers and that we are glued together . . . (try some times until the student really has it).

Now we will use the same idea when we hold the mallets. Of course it is in a smaller sense, but we keep thinking of the good handshake, prolonging the fingers around the mallet shafts and imagine they are glued to the fingers. With that idea play the exercise again:

A.2 Control group

Play a little on the instrument with these mallets to feel comfortable. 2 min

Does the height of the instrument suit you? (make changes)

Play this little exercise, which consists of a C-major chord repeated 5 times as written. Please strike the bars where the arrows point:

Now focus on the sound you create – repeat the exercise with as open and warm sound as you can.