

General

Teaching music using vibration

Professor Carl Hopkins, Mrs Natalie Barker and Dr Gary Seiffert from the University of Liverpool give us an insight into their research project

Background research

One of the research themes of the Acoustics Research Unit at the University of Liverpool is the use of vibration to facilitate music-making by deaf musicians. Our initial research focused on interactive musical performance. The idea was to facilitate group rehearsal, performance and improvisation by simultaneously transmitting different vibration signals to different musicians. The basic concept was that any musical performance would effectively become an amplified musical performance where the sound from each instrument is taken to a mixing desk and sent back as a vibration signal to be presented to the musician's body – see Figure 1.

The 'sensors' that are embedded in human skin to perceive

vibration are not as sensitive as those in the ear, so our initial research was used to establish the lowest level of vibration that could be perceived on the fingertips, heel and forefoot over a range of musical notes. This was based on the use of relatively large discs on which bare feet or hands could be placed whilst playing or singing. Prior to our research, the highest musical note at which it was feasible to perceive continuous vibration at a safe level had not been identified. From our experiments we concluded that musical notes from C1 to G5 were feasible for the presentation of music to the hands and feet. This range of notes is more limited than human hearing but the pitch of the human voice, and the fundamental notes of many instruments, lie within this range. However, it is well-established that exposure to excessive levels of vibration

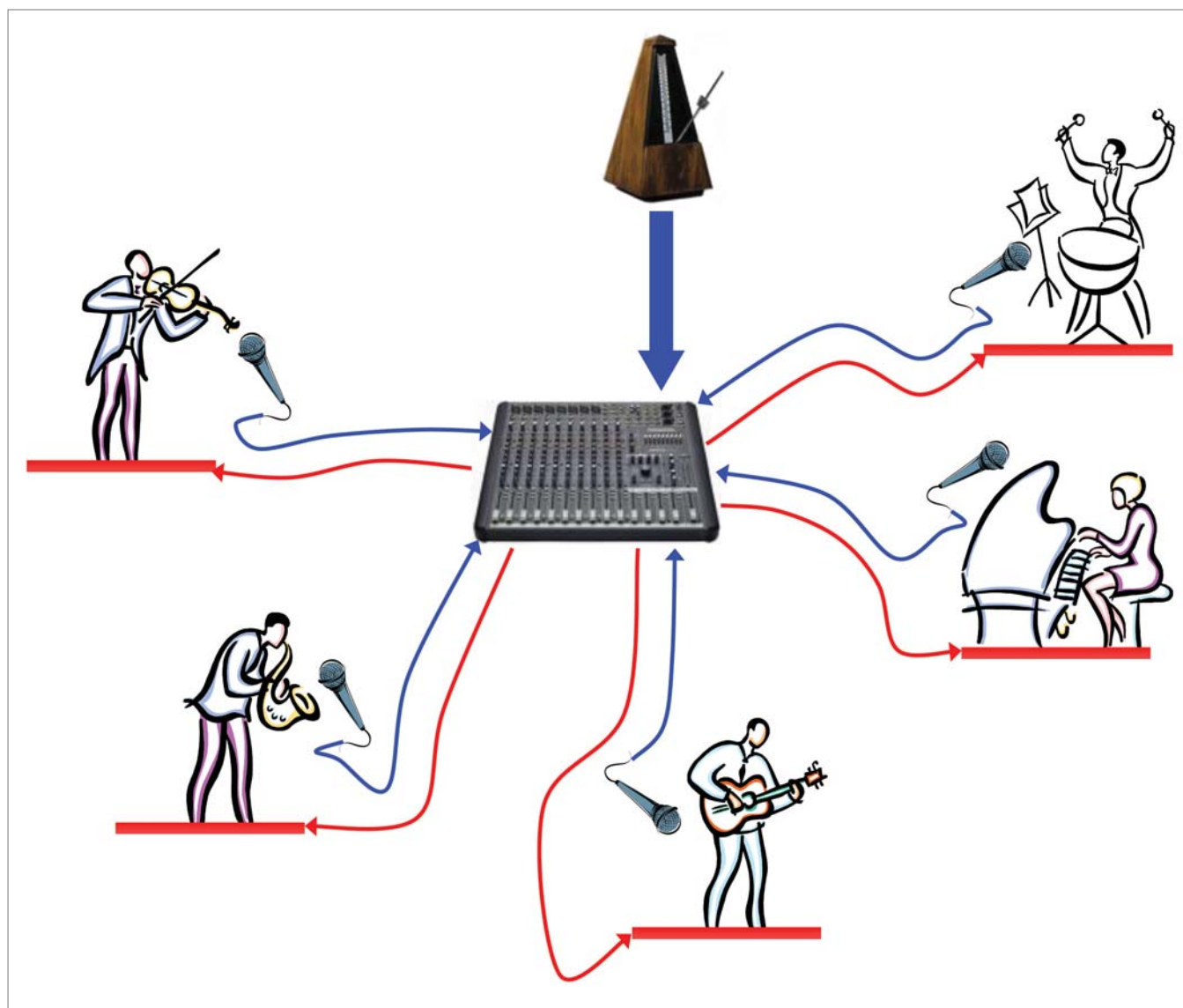


Figure 1. Concept for interactive performance using vibrotactile feedback. Blue lines represent sound picked up by microphones that is taken to the mixing desk. Red lines represent the 'mixed' signal which is sent as vibration to the musician.



Figure 2. Vibrotactile equipment in the music classroom at the Royal School for the Deaf Derby. Six large shakers for the feet are positioned on the floor, with two smaller finger shakers (encased in grey boxes) next to the mixing desk. (See the shakers in use at <https://stream.liv.ac.uk/2qvwd9th>)

can cause health problems, for example, white finger experienced by workers using pneumatic drills without protection. Hence, the next step was to identify safe levels of vibration that would allow musicians, whether amateur or professional, to practise or perform for relatively long periods of time whilst avoiding adverse health effects. By identifying the lower and upper limits of vibration it was clear that the available dynamic range and the perceivable range of musical notes made the initial idea feasible. The last step was to use psychophysical experiments to check that it would be possible to make judgements on relative pitch (the ability to recognise that one note is higher or lower than another) for 'simple' musical tones. The results showed that judgements of relative pitch were possible and could be improved with simple, repetitive training sessions, although the smallest interval of a semitone remained challenging even after training.

Vibrotactile equipment

Most commercially available equipment is designed to present strong drum beats from dance music (eg vibrating jackets) to the chest and back; hence they are rarely able

to deliver uniform vibration levels across a range of musical notes. Moreover, these devices have little or no clear traceability to safe levels of vibration for children. For this reason, we use the same electrodynamic shakers that were used in the original research to 'deliver' the vibration. These devices are widely used in acoustics research and in test laboratories in the automotive or mechanical industries for vibration testing. They have the advantage that they have a uniform vibratory response over a range of musical notes and can withstand the weight of the leg of a seated person. The other equipment needed is quite standard: an amplifier for each shaker, a signal limiting device (to ensure safe levels of vibration) and a mixing desk. Figure 2 shows the shakers installed in a music classroom. For a musician playing an instrument with their hands it is often possible to feel four different instruments by using the heels and toes of both feet. A singer has more flexibility as they are often able to use both hands and feet.

Royal School for the Deaf, Derby

A set of vibrotactile equipment with several shakers was installed in the Royal School for the Deaf Derby (RSSD) in

Spring 2019. The responses of staff and pupils at the school who used the vibrotactile equipment in their music lessons are documented in a professional-filmed video (see <https://stream.liv.ac.uk/2qwvd9th>). We were fortunate that Matthew Taylor, the music teacher, was so open and interested in trying out the equipment with his pupils. Matthew developed new lesson plans to integrate vibration into the way he taught music, noting that the equipment worked equally well for small groups, one-to-one sessions, or paired learning activities.

Matthew designed new tasks based around pitch recognition. A series of notes would be played on a keyboard or bass guitar. Pupils were asked to decide whether each note was high, middle or low in pitch. It became apparent that once pupils had access to high-quality vibrotactile feedback, many appeared confused about what constituted high and low pitch, a key musical concept. This is because low-pitched notes naturally produce a more intense vibratory sensation and pupils were conflating 'a high quantity of vibration' with 'high pitch', when the reverse is true. This later prompted Matthew to change the way he marked up the keyboards. Previously, like many music teachers, he colour-coded individual pitches within each octave, but since using the equipment he now colour codes entire octaves to emphasise the overall difference between low and high pitch, rather than the more subtle difference between individual pitches. In combination with vibration this was a more effective way of helping pupils to find, compose and play pitched melodies accurately. Building on these pitch perception tasks, pupils would try and identify a melody from a series of choices, only one melody being correct.

Additional educational value was evident in behavioural changes with Matthew commenting "I've noticed a great kind of improvement in engagement in lessons from a lot of our students...a lot of the teamwork that begins happening is quite impressive to see...all the children are very interested in music now and they really enjoy working together...the social interaction between them has really improved in some cases." Teaching support staff also commented on the increased engagement of pupils, as evidenced by their oral communication and facial expression.

Matthew highlighted an additional safety benefit of using vibration in that it leads to lower sound pressure levels in the classroom such that he did not need earplugs to protect his hearing as there was no need to increase the volume from loudspeakers. With the vibrotactile equipment, he had greater control and it created a much calmer atmosphere in the classroom. In conclusion, Matthew said that introducing vibration as a teaching tool "had been a great success, and a thoroughly positive experience" that had "made many aspects of music as a school subject at RSDD more interesting and engaging for many of our pupils".

As part of an educational programme on orchestral music, Marianne Barraclough (Education Manager at Sinfonia Viva) ran workshops with RSDD pupils in the Summer of 2019 where she had initially noted the difficulty in teaching deaf pupils saying: "...in this large group of young people we were really struggling to kind of maintain a group pulse."; however, "...as soon as we were able to start using the vibrotactile equipment that suddenly became possible. It meant that we went from finding the sessions really frustrating...and finding that it wasn't totally satisfactory for every[body], anybody really, to finding that actually by using the vibrations...we were all able to play together and from that point we could actually make some music. By overcoming barriers to group working, this opened up new avenues for musical exploration: "...maintaining focus was a challenge through the sessions...but when we were using the vibrotactile kit it provided that focus and meant that we were all locking in to the same rhythm...we were even able to do things like call-and-response which didn't seem at all like that would be possible when we started the project."

Musical Vibrations

To try and reach a wider audience with our research we branded the vibrotactile concept for education, performance, production and appreciation as 'Musical Vibrations'. This led to our website, www.musicalvibrations.com – which is used to disseminate information on our approach to demonstrate the potential of vibrotactile feedback to support people who are deaf in music performance, education, appreciation and production. This website has links to other videos. We have interviews with the London based hip-hop producer, writer and performer, SignKid, who used our equipment for music production in his home studio whilst composing his new EP. We also have a video with a lady who experienced sudden-onset deafness in mid-life and is now profoundly deaf. Using our equipment, she sang along in time with one of her favourite Phil Collins' songs from a time when she still had her hearing. Her response was highly enthusiastic saying, "I was absolutely lost in the feeling of the drums in the beat in the senses. I could 'hear'. It's a sensation that brought real joy to me...it was as if it all joined up in my brain to produce 'sound'. I have memories of songs and through the vibrations I was feeling the sound I remember was produced in my head."

If you are interested in using the vibrotactile equipment for music teaching in your school, please get in contact via our website, www.musicalvibrations.com



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