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Visual Feedback in Higher Education Piano Learning and Teaching

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ABSTRACT

Feedback is crucial for learning; in piano learning, feedback is both intra- and inter-personal. Evidence indicates that the application of visual feedback can enhance instrumental and singing learning. However, what is not yet clear is exactly how visual feedback might be used in higher education piano studios. An exploratory study (Hamond, 2017) was conducted to investigate the pedagogical uses of additional visual feedback generated by technology in higher education piano studios. Three teacher-student pairs in higher education in Brazil and the researcher, as technology-mediator, participated in this study. Each pair chose a movement of a classical sonata of their current repertoire to work on in two piano lessons. The technology system involved a digital piano, connected with a laptop running Digital Audio Workstation (DAW) software (Cockos' Reaper) via MIDI interface, and an additional PC screen. Data collection encompassed the video observation of two lessons, interviews with participants, and MIDI data. A multi-methods Qualitative Data Analysis (QDA) was used: thematic analysis for videos and interviews, microstructure analysis of musical behavior in videoed lessons, and MIDI QDA. Real-time and post-hoc visual feedback was generated by the technology system, combined or not with auditory feedback. Results indicated that additional visual feedback can augment intrapersonal feedback, enhance conscious-awareness of students' performances and subsequently enhance learning and performance. Teacher-student pairs differed in preferences when using either auditory or visual feedback.

I. INTRODUCTION

Feedback makes learning possible. The impact of feedback on learning has been indicated in the literature of cybernetics (Schwartz & Andrasik, 2003; Annett, 1969; Wiener, 1961), motor control and learning (Gibson, 1968; Magill, 1989; Schmidt & Lee, 2011), music learning (e.g. Welch, 1983, 1985a, 1985b) and one-to-one instrumental and vocal learning (Creech & Gaunt, 2012, for an overview). A master-apprenticeship model has been noted in one-to-one instrumental and vocal learning in several studies (e.g. Hallam, 1998; Jørgensen, 2000) 'where the dominating mode of student learning is imitation' (Jørgensen, 2000, p. 68). Some research has highlighted the supportive use of technology in one-to-one instrumental learning 'as a medium of transformative change' (Creech & Gaunt, 2012, p.701) towards 'student reflection, autonomy [and] motivated, self-directed learning' (Creech & Gaunt, 2012, p. 703).

The provision of feedback is a crucial aspect of ensuring learning in educational environments. Feedback can be defined as the "information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (Hattie & Timperley, 2007, p.81). In instrumental and vocal learning, the nature of feedback is both intra- and interpersonal (Hamond, 2017; Welch et al., 2005). Intrapersonal feedback occurs within the individual (i.e. the student) and primarily involves the sensory system. In piano learning and playing, intrapersonal feedback is mainly auditory (Banton, 1995; Finney, 1997), visual (Banton, 1995; Bishop & Goebl, 2015) and proprioceptive (Brown & Palmer, 2012; Wöllner & Williamon, 2007). Intra-personal feedback in piano learning also encompasses other internal processes such as the conscious-awareness state of the individual (Acitores, 2011), metacognitive knowledge (Hallam, 2001), self-regulatory skills (Nielsen, 2001), and a sense of self (Damasio, 2000) which also play their roles in learning.

In piano learning and teaching, there are two types of inter-personal feedback: (a) between the teacher and the student; and (b) between individuals and a technology system. Interpersonal feedback involves information which is delivered by the teacher in order to improve a student's performance. Inter-personal feedback in piano learning is both verbal and non-verbal. Types of verbal and non-verbal feedback in piano learning were observed in several studies (Benson & Fung 2005; Burwell 2010; Hamond 2013; Siebenaler 1997). Types of verbal feedback involve: giving directions or instructions, providing information, asking questions, offering general feedback – positive, negative or ambiguous, and also off-task comments. Types of non-verbal feedback encompass: teacher's playing or singing, teacher's modelling, teacher's imitating student's playing, making hand gestures, body movements, conducting, tapping the pulse, and also smiling, laughing, nodding, shaking, as well as using other facial expressions.

Interpersonal feedback can also occur between individuals and technology. The perspectives of teachers, expert pianists and students on the use of technology in instrumental learning have been investigated in several studies (Benson, 1998; Daniel, 2001; Riley, 2005; Tomita & Barber, 2008). Various types of technology have been investigated in these studies: video recording (Daniel, 2001), MIDI protocols and piano roll visualization (Riley, 2005; Tomita & Barber, 2008), and instructional media (Benson, 1998). However, these studies investigated the application of technology based on student self-reports and self-assessment (Benson, 1998; Daniel, 2001; Riley, 2005; Tomita & Barber, 2008).

The application of real-time visual feedback, as a new technology system, has been investigated by several studies in instrumental and vocal learning (Brandmeyer, 2006; Sadakata et al., 2008; Welch, 1983, 1985b; Welch et al., 2005). Real-time visual feedback was researched in tapping and percussion learning when imitating rhythms (Brandmeyer, 2006; Sadakata et al., 2008). The benefits and limitations of

using real-time visual feedback were investigated in higher education singing studios (Welch, 1983, 1985b; Welch et al., 2005).

Different types of technology have been used in piano-related studies (François, Chew, & Thurmond, 2007; Himonides, 2012; McPherson, 2013). Measurements and assessments of piano performance practices and /or improvisations have been conducted when using different types of technologies with visual feedback (François et al., 2007; McPherson, 2013). However, the use of technology in higher education piano studios, especially for the use of additional visual feedback, seems to be under-researched.

II. METHOD

For this research I used an action-case study (Braa & Vidgen, 1999), a hybrid methodology where aspects of case study and action research can be combined. Data collection involved three sources: video recording of two piano lessons (n = 6), audio recorded interviews with teachers and students separately (n = 12) after each piano lesson, and technology-generated MIDI data. A multi-method qualitative data analysis approach was adopted in this study: thematic analysis (Braun & Clarke, 2008) was adopted for video and interview data, microstructure analysis of the musical behaviour such as playing and listening back (Demos & Chaffin, 2009), as well as MIDI technology-generated data qualitative data analysis.

A. Ethical Review

This study used British Educational Research Association (BERA, 2011) guidelines and obtained ethical approval by the advisory committee of the UCL Institute of Education, University College London. All the participants received an information leaflet describing the nature of this research and the confidentiality of this study. Although participation in this study was voluntary, participants had their travel expenses reimbursed. Participants had the opportunity to ask the researcher questions about the study in advance. They also signed a consent form before taking part in the study.

B. Participants

The participants (n = 6) in the study were three piano teachers and one of their piano students (principal or second instrument) in higher education in Brazil. At the time the data was collected (between November 2013 and February 2014) the piano teachers had an average age of 49, while the average age of the piano students was 26. Teachers had an average of 25 years' teaching experience. Participants had to fall into the following criteria to be part of thes study: (a) be teacher-student pairs in higher education; (b) have worked on a regular weekly one-to-one basis for at least one term; and (c) have chosen a memorized piece from their current repertoire to work on in two piano lessons with the technology system. The three pairs chose to work on one movement of a classical sonata. The researcher also participated in this study by playing the facilitator role with the technology system in two piano lessons. The three pairs are called case studies A, B and C. Students in case study B and C were principal instrument piano students whilst the student in case study A was a second instrument piano student.

C. Materials

The technology system encompassed: a digital piano, two MIDI cables, a laptop computer running Cockos' Reaper DAW software with piano roll screen option via a MIDI interface, one additional PC computer screen to be placed in front of the piano student, and one VGA cable to connect the laptop computer and the additional PC screen. The technology system allowed the collection of MIDI data on the DAW software. The equipment used to collect the video and interview data involved: two digital cameras, two tripods for the digital cameras, and one voice recorder.

D. Procedure

Each teacher-student pair had two piano lessons videoed alongside the application of the technology system which was facilitated by the researcher (the author). During the two piano lessons, a large amount of MIDI technology-generated data was recorded at the DAW software Cockos' Reaper whilst participants played the piano; this data could be played back alongside visualizations of participants' performances as a piano-roll form. The main data collection and analyses were video and MIDI. Interviews were conducted in order to complement the findings from the video and MIDI QDA. Semi-structured interviews were conducted after each piano lesson with each participant separately. The interviews focused on participant perspectives on the application of this technology system, particularly visual feedback, in a higher education piano studio. Participants' reports on their background, piano learning and teaching experiences, were also examined. In the piano lessons, teacher-student pairs were asked to choose a memorized piece from their current repertoire. The chosen piano pieces were one movement of a classical sonata: (a) Mozart Piano Sonata No.16 in C major, K.545, 2nd movement, in case study A; (b) Beethoven Piano Sonata No.9 in E major, Op.14 No.1, 1st movement, in case study B; and (c) Mozart Piano Sonata No.2 in F major, K.280, 1st movement, in case study C. All students also brought the respective scores to the lessons so that their teachers could check the musical notation whilst they were playing. The average duration of each lesson was 55 minutes. The interval between the first and second lessons was 4 days in case study A, 9 days in case study B, and 7 days in case study C. These lesson interval differences do not appear to have interfered with the results of this study. Each piano lesson was video recorded using two digital cameras: one camera captured the interaction between the participants and the other camera focused on what was happening on the additional PC screen.

E. Analysis

A multi-method qualitative analysis was adopted in this study. Video QDA involved the thematic analysis of the videoed lessons for: (1) the nature of feedback; (2) the pedagogical uses of technology-mediated feedback; and (3) additional auditory feedback accordingly with the musical behaviour. MIDI QDA encompassed the qualitative analysis of the performance-related data which was available on the computer screen after being recorded on the DAW software. Interview QDA involved the thematic analysis of the interview data by complementing the findings of the two main sources: video and MIDI. A triangulation of data collection and analysis was conducted in order to ensure trustworthiness

and assure quality criteria in this qualitative research study (Guba, 1981; Shenton, 2004).

III. RESULTS

Findings of the video QDA suggested that the nature of interpersonal feedback (between teacher and student) is verbal and non-verbal feedback. Types of verbal feedback were related to the following behaviours: providing information, giving direction, and asking questions. Types of non-verbal feedback were linked with the following behaviours: head and body movements, hand gestures, pointing (to the music score or computer screen), playing and singing. Types of verbal and non-verbal feedback were related with three main areas: music, performance and technology. Music regarded the aspects of musical notation, and musical structure of the piece. Performance was linked to aspects of the musical performance such as dynamics, articulation, melodic and rhythmic accuracy, phrasing and pedalling. Technology was related to the MIDI parameters, i.e. MIDI note colours, sizes, asynchrony, key velocity number, MIDI recording version, and digital piano use.

Video QDA focused on the pedagogical technology-mediated feedback uses which were facilitated by the researcher in the piano lessons. Results of this video QDA suggest that pedagogical uses of this technology system can be: (1) in real-time; (2) post-hoc in the original tempo; (3) post-hoc at a slower tempo; and (4) silent post-hoc (without auditory feedback). Real-time feedback use was available to participants when participants played the digital piano whilst the researcher recorded the performance-related data. Post-hoc feedback use was available to participants when the researcher played the previously recorded performance-related data back to participants. Post-hoc feedback use involved listening back to the performance-related data or/and seeing the piano-roll visualization of the performances for enhancing piano learning and performance. Post-hoc feedback could be: (a) in the original tempo when the performance-related data was played back exactly the same as it was played/recorded; and at a slower tempo when the performance-related data was played back at half speed of the original tempo. Post-hoc feedback could also be: (a) normal when auditory feedback was available; and (b) silent when auditory feedback was not available (visual feedback only). The three case studies used post-hoc feedback in the original tempo. However, some pedagogical uses of technology-mediated feedback were particular to each case study. Real-time feedback use for individual experience and silent post-hoc feedback use was a characteristic of case study A. Real-time feedback for shared experience featured in case study B. Post-hoc feedback use at a slower tempo was an observed characteristic of case study C.

Video QDA for musical behaviours examined pedagogical uses of additional auditory feedback across case studies. Auditory feedback which was available in lessons was systematically analysed through the use of the Study Your Musical Practice (SYMP) software developed by Demos & Chaffin (2009) for individual musical practice. In this study, the SYMP software template was customized for musical behaviours (playing and listening back) in piano lessons with the application of technology-mediated feedback. Findings of this video QDA suggested that additional auditory feedback could be: (1) in real-time for the moments where the participants were playing the piano; (2) and post-hoc for the moments where participants listened back to their recorded performance-related data. Additional auditory feedback involved auditory feedback which was not commonly found in one-to-one piano lessons: this was post-hoc feedback which was combined with visual feedback. Additional auditory feedback varied in three aspects: (a) performer (the student, the teacher, or both); (b) the musical excerpt (the bar group of the musical structure of the piano piece); and (c) the version of the recorded performance data (1st version, 2nd version, etc.).

MIDI QDA focused on the pedagogical uses of additional visual feedback in piano lessons with the application of technology-mediated feedback. Findings of MIDI QDA suggested that visual feedback could be: in real-time (Figure 1) and post-hoc (Figure 2). Real-time or post-hoc visual feedback use involved seeing the piano-roll visualization of the performances for enhancing piano learning and performance whilst playing/recording or seeing/playing back the performance-related data. Real-time feedback use happened for two purposes: (a) individual experience: when the student used it for their own learning needs; and (b) shared experience: when both teacher and student used it for a particular lesson focus. Post-hoc feedback use was available to participants when the researcher played the previously recorded performance-related data back to participants. Post-hoc feedback use happened in three categories: (a) shared experience purpose when the teacher was working alongside student with visual feedback combined with auditory feedback; (b) silent mode purpose (visual feedback only); and (c) attentive listening purpose. Findings of the MIDI QDA suggest that additional visual feedback can make the lesson focus clearer for the following parameters: articulation, dynamics, melodic and rhythmic accuracy, as well as pedal use. An example of a musical excerpt and the respective additional visual feedback in real-time and post-hoc of the performance-related data generated by the technology system is given below.

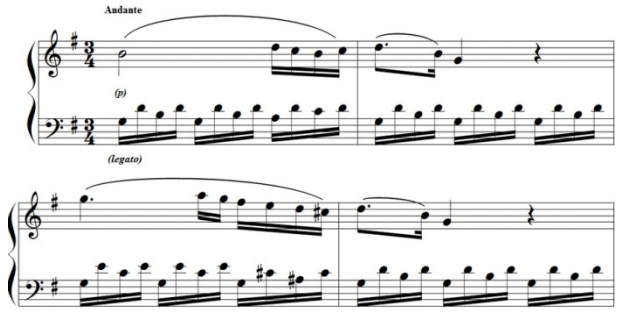

Figure 1. Musical excerpt of Mozart Piano Sonata No. 16 in C major, K. 545, second movement, bars 1-4

Figure 2. DAW software screenshot for the real-time visual feedback use in case study A

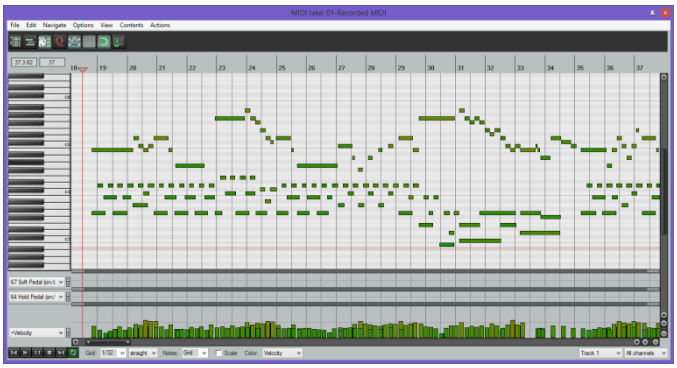

Figure 3. DAW software screenshot for the post-hoc visual feedback use in case study A

Interview QDA investigated the perspectives of participants on several aspects: ideal lesson, the pedagogical uses of real-time visual feedback, post-hoc auditory feedback and post-hoc visual feedback, and musical performance parameters which could be worked on when this technology was used in piano lessons. As a preliminary stage, teachers across case studies reported their aim in teaching the students to listen to themselves, i.e. to listen to their performances perhaps as the teachers do. Findings of interview QDA suggested that the use of technology-mediated feedback in piano lessons has enhanced conscious-awareness of the pieces. Teachers and students reported that post-hoc feedback use was beneficial since students listened to their performances solely instead of listening and playing at the same time as happens in a conventional one-to-one piano lesson. A change in the learning process was noticed by both students and teachers. The use of technology-mediated feedback made the lesson foci clearer and well-defined, and also made the learning process quicker. However, students and teachers disagreed when they reported on the changes in the teaching approaches. Students noted that the use of this technology system brought a change to the piano studio environment, since it allowed them to focus on listening immediately after playing the piano piece rather than playing it and listening at the same time. In contrast, teachers did not perceive a change in their teaching styles since they were focusing on aspects which they usually work on alongside students in conventional piano lessons such as articulation, dynamics, and phrasing, as well as use of the technology system.

IV. CONCLUSION

Visual feedback generated by technology was used pedagogically in higher education piano studios. The pedagogical uses of additional visual feedback encompassed: in real-time and post-hoc which are not commonly available in one-to-one conventional piano lessons. In line with Welch et al. (2005) in the singing studio context, real-time visual feedback generated by technology can benefit piano learning and teaching since the teacher can assess student performance in real-time whilst it has been played and recorded. Welch et al. (2005)'s study have discussed the use of real-time visual feedback for enhancing particular musical performance parameters and specific voice parameters. This study suggests that real-time visual feedback can enhance piano learning and performance for articulation, and melodic accuracy.

Findings of this study complement those of previous research in RTVF instrumental and vocal learning (Brandmeyer, 2006; Sadakata et al., 2008; Welch, 1983, 1985b; Welch et al., 2005). In this current study, performance-related data can be recorded, saved, stored and also played back so that the teacher and the student can compare recorded data and discuss this according to their lesson focus.

This study also complements previous piano-related studies (Benson, 1998; Daniel, 2001; Riley, 2005; Tomita & Barber, 2008), particularly those studies (Riley, 2005; Tomita & Barber, 2008) which suggested the use of MIDI protocols and piano roll based on perspectives of piano students when attending a demonstrative workshop showing its benefits. The pedagogical uses of visual feedback, in the form of piano roll visualization of the correspondent performance, were explored in piano studios with teacher feedback alongside student performance in this study.

Visual feedback uses in higher education piano studios augmented intrapersonal feedback not only in terms of auditory feedback (Banton, 1995; Finney, 1997) but also in terms of proprioceptive feedback (Brown & Palmer, 2012; Wöllner & Williamon, 2007) since students became more conscious-aware of their own piano learning and performance. Metacognitive knowledge (Hallam, 2001), self-regulatory skills (Nielsen, 2001), and sense of self (Damasio, 2000) might have been augmented since they function as internal processes for the intrapersonal feedback of the individual. However, visual feedback uses seemed to depend on the level of interaction between the individual and technology, as well as their preferences in using either auditory or visual feedback.

The pedagogical uses of visual feedback were demonstrated to have similar and different characteristics from a one-to-one conventional piano lesson, which is in line with Savage (2007). Similar characteristics are related to the types of verbal and non-verbal feedback linked to music notation and performance which are commonly available in piano lessons (Benson & Fung 2005; Burwell 2010; Hamond 2013; Siebenaler 1997). Different characteristics are related to the type of verbal and non-verbal feedback on technology aspects which can also be associated with music notation and performance and promote associative learning (Brown & Palmer, 2012; Mathias et al., 2015). These similar and different characteristics of the pedagogical uses of visual feedback might have impacted the different views of students and teachers on the changes in teaching approaches, even though a change in the learning process was agreed.

Future research is needed in order to explore the application of this new pedagogical tool in a longitudinal study. Other aspects which can also be investigated are: the frequency of use of the technology system, the appropriateness of repertoire, the level of expertise of the student, and the stage of the learning process (i.e. sight-reading, memorisation, etc.).

In conclusion, visual feedback generated by technology can optimize traditional one-to-one piano pedagogical approaches. Outcomes of this research might benefit and impact a student's self-study and performance monitoring prior to a live performance, digital piano instrument learning and performance, and evaluation of teacher's feedback effectiveness.

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REFERENCES

Acitores, A. P. (2011). Towards a theory of proprioception as a bodily basis for consciousness in music. In D. Clarke & E. Clarke (Eds.), *Music and consciousness: Philosophical, psychological, and cultural perspectives* (pp. 215-231). Oxford: Oxford University Press.

Annett, J. (1969). Feedback and human behaviour: the effects of knowledge of results, incentives and reinforcement on learning and performance. Harmondsworth: Penguin.

Banton, L. J. (1995). The role of visual and auditory feedback during the sight-reading of music. *Psychology of Music, 23*(1), 3-16. doi: 10.1177/0305735695231001

Benson, C. (1998). The effects of instructional media on group piano student performance achievement and attitude. (D.M.A.), University of Texas, Austin.

Benson, C., & Fung, C. V. (2005). Comparisons of teacher and student behaviors in private piano lessons in China and the United States. *International Journal of Music Education, 23*(1), 63-72. doi: 10.1177/0255761405050931

BERA (2011). *Ethical Guidelines for Educational Research 2011*. Retrieved from https://www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2011 [Last accessed 23/08/2016]

Bishop, L., & Goebl, W. (2015). When they listen and when they watch: Pianists' use of nonverbal audio and visual cues during duet performance. *Musicae Scientiae, 19*(1), 84–110. doi: 10.1177/1029864915570355

Braa, K., & Vidgen, R. (1999). Interpretation, intervention, and reduction in the organizational laboratory: a framework for in-context information system research. *Accounting, Management and Information Technologies, 9*(1), 25-47.

Brandmeyer, A. (2006). *Real-time visual feedback in music pedagogy: Do different visual representations have different effects on learning?* (MSc). Radboud University, Nijmegen.

Braun, V., & Clarke, V. (2008). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. doi: http://dx.doi.org/10.1191/1478088706qp063oa

Brown, R. M., & Palmer, C. (2012). Auditory-motor learning influences auditory memory for music. *Memory & Cognition, 40*(4), 567-578. doi: 10.3758/s13421-011-0177-x

Burwell, K. (2010). *Instrumental teaching and learning in Higher Education*. (PhD). University of Kent, Canterbury.

Creech, A., & Gaunt, H. (2012). The changing face of individual instrumental tuition: Value, purpose and potential. In G. McPherson & G. Welch (Eds.), *The Oxford Handbook of Music Education* (Vol.1, pp. 694-711). Oxford: Oxford University Press.

Damasio, A. (2000). The feeling of what happens : body and emotion in the making of consciousness. London: Heinemann.

Daniel, R. (2001). Self-assessment in performance. *British Journal of Music Education, 18*(3), 215-226.

Demos, A. P., & Chaffin, R. (2009). A software tool for studying music practice: SYMP (Study Your Music Practice). *Poster presented at the European Society for the Cognitive Sciences of Music (ESCOM)*, Jyväskylä, Finland. Retrieved from http://musiclab.uconn.edu/wp-content/uploads/sites/290/2013/10/DemosESCOM-Poster.pdf [Last accessed 23/08/2016]

Finney, S. A. (1997). Auditory feedback and musical keyboard performance. *Music Perception, 15*(2), 153-174.

François, A. R. J., Chew, E., & Thurmond, D. (2007). Visual feedback in performer-machine interaction for musical improvisation. *Paper presented at the NIME07*, New York, NY. Retrieved from http://www.nime.org/proceedings/2007/nime2007_277.pdf [Last acessed 23/08/2016]

Gibson, J. J. (1968). The Senses Considered as Perceptual Systems. London: Allen & Unwin.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology, 29*(2), 75-91.

Hallam, S. (1998). Instrumental teaching: a practical guide to better teaching and learning. Oxford: Heinemann.

Hallam, S. (2001). The development of metacognition in musicians: implications for education. *British Journal of Music Education, 18*(1), 27-39. doi: 10.1017/S0265051701000122

Hamond, L. (2013). Feedback on elements of piano performance: Two case studies in higher education studio. In A. Williamon & W. Goebl (Eds.), *Proceedings of the International Symposium on Performance Science 2013* (pp. 33-38). Brussels: European Association of Conservatoires.

Hamond, L. (2017). *The pedagogical use of technology-mediated feedback in a higher education piano studio: an exploratory action-case study.* (PhD), University College London, Institute of Education, London.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112. doi: 10.3102/003465430298487

Himonides, E. (2012). The misunderstanding of music-technology-education: A Meta Perspective. In G. McPherson & G. Welch (Eds.), *The Oxford Handbook of Music Education* (Vol. 2, pp. 433-456). Oxford: Oxford University Press.

Jørgensen, H. (2000). Student learning in higher instrumental education: who is responsible? *British Journal of Music Education, 17*(1), 67-77.

Magill, R. A. (1989). Motor learning: concepts and applications. (3rd ed.). Dubuque, IA: Wm. C. Brown.

Mathias, B., Palmer, C., Perrin, F., & Tillmann, B. (2015). Sensorimotor learning enhances expectations during auditory perception. *Cerebral Cortex, 25*(8), 2238-2254. doi:10.1093/cercor/bhu030

McPherson, A. (2013). *Portable measurement and mapping of continuous piano gesture*. Paper presented at the Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2013), Seoul, Korea. Retrieved from

http://nime.org/proceedings/2013/nime2013_240.pdf [Last accessed 23/08/2016]
Mozart, W. A. (1938). *Sonaten für Klavier zu zwei Händen* [Piano Sonatas], K. 545 [Piano score]. Leipzig: Peters (Original work published 1788). Retrieved from http://imslp.org/ on 21/12/2015.
Riley, K. (2005). Understanding piano playing through students' perspectives on performance analysis and learning. *American Music Teacher, 54*(6), 33-37.
Sadakata, M., Hoppe, D., Brandmeyer, A., Timmers, R., & Desain, P. (2008). Real-time visual feedback for learning to perform short rhythms with expressive variations in timing and loudness. *Journal of New Music Research, 37*(3), 207-220. doi: 10.1080/09298210802322401
Savage, J. (2007). Reconstructing music education through ICT. *Research in Education, 78*(1), 65-77.
Schmidt, R. A., & Lee, T. D. (2011). Motor control and learning : a behavioral emphasis. (5th ed.). Champaign, IL: Human Kinetics.
Schwartz, M. S., & Andrasik, F. (2003). Biofeedback: A practitioner's guide. New York, NY: Guilford Press.
Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63-75.
Siebenaler, D. J. (1997). Analysis of teacher-student interactions in the piano lessons of adults and children. *Journal of Research in Music Education, 45*(1), pp. 6-20.
Tomita, Y., & Barber, G. (2008). New technology and piano study in higher education: Getting the most out of computer-controlled player pianos. *British Journal of Music Education, 13*(2), 135-141. doi: 10.1017/S0265051700003107
Welch, G. F. (1983). *Improvability of poor pitch singing: experiments in feedback*. (PhD). Institute of Education, University of London, London.
Welch, G. F. (1985a). A schema theory of how children learn to sing in tune. *Psychology of Music*, 13(1), 3-18.
Welch, G. F. (1985b). Variability of practice and knowledge of results as factors in learning to sing in tune. *Bulletin of the Council for Research in Music Education*, 85, 238-247.
Welch, G. F., Howard, D. M., Himonides, E., & Brereton, J. (2005). Real-time feedback in the singing studio: an innovatory action-research project using new voice technology. *Music Education Research*, 7(2), 225-249. doi: 10.1080/14613800500169779
Wiener, N. (1961). Cybernetics: or, control and communication in the animal and the machine. Cambridge, MA: The MIT Press.
Wöllner, C., & Williamon, A. (2007). An exploratory study of the role of performance feedback and musical imagery in piano playing. *Research Studies in Music Education, 29*(1), 39-54. doi: 10.1177/1321103X07087567