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Are We Really Hearing in Our Heads What We Think We're Hearing? The Role of Audiation in Musical Improvisation.

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Abstract

An important and valued part of the skill of musical improvisation is to be able to play what we hear in our head (audiation). Improvisation is a cognitively demanding activity, involving the production of musical material in real time. This requires the simultaneous involvement and coordination of many different skills, and places demands on working memory, memory retrieval, auditory and sensory-motor systems. Some recent studies support a cognitive model of improvisation which posits the deployment of stored rhythmic and melodic patterns via motor programmes. According to the theory of event coding, actions and their perceptual consequences share the same cognitive representation and behavioural and fMRI studies have offered evidence supporting this theory. Since musical actions have sounds as perceptual consequences and sensorimotor coupling is bidirectional, this is compatible with improvisers imagining the sounds as they play them. However, phenomenological accounts and interview studies suggest musicians use different strategies to generate ideas in improvisation, such as music-theoretic ideas and motor patterns or 'muscle memory'. So questions remain regarding the precise role of audiation in improvisation: what is musicians' experience of musical imagery as they improvise? Is auditory imagery cognitively prior to action or post hoc? How accurate is auditory imagery? What proportion of musical output involves audiation and how sensitive is this to context? The aim of this paper is to offer a coherent explanatory framework for improvisation from the perspective of cognitive psychology and to propose experimental paradigms to begin to answer some of these questions. On the basis of a review of the literature, it is concluded that two approaches offer a way forward: altered auditory feedback (AAF) and a blocking paradigm in which interference conditions seek to disrupt the tonal loop in working memory.

Keywords: Audiation, improvisation, common coding, altered auditory feedback, tonal loop

Introduction

'Audiation' is a term coined by Edwin Gordon (1979) and in this context it means imagining the music being improvised. Musical improvisation is a complex human activity which also has different meanings in different contexts and resists easy definition. The focus in this paper is on jazz improvisation in a tonal context which is a process involving the composition or selection and deployment of musical material in real time.

Improvisation has proved difficult to investigate experimentally, due to the involvement of many rapid simultaneous cognitive processes and its inherent unpredictability. Some progress has been made in this area recently however, using methods such as computer analysis of solos (Norgaard, 2014), algorithmic generation (Norgaard, Spencer, & Montiel, 2013; Pachet, 2012), behavioural experiments (Goldman, 2013) and fMRI (Donnay, Rankin, Lopez-Gonzalez, Jiradejvong, & Limb, 2014; Limb & Braun, 2008).

Brain scanning techniques (fMRI, EEG, MEG) have also been used to investigate auditory imagery (audiation) in other contexts, such as silent score reading (Brodsky, Kessler, Rubinstein, Ginsborg, & Henik, 2008) and in comparison to perception (Schaefer, Desain, & Farquhar, 2013). However, questions remain regarding the role of audiation in the improvisatory context because the brain regions hypothesized to be involved in imagery overlap with those involved in perception and motor planning (Zatorre & Halpern, 2005), which are also integral to improvisation. How accurate

and how detailed is audiation? When does it occur in the process?

Also, interviews with artist-level musicians indicate that they use a variety of strategies for idea generation when improvising (Hargreaves, 2012; Norgaard, 2011). Some of these, such as 'muscle memory' or strategies based on music-theoretic considerations do not seem to necessitate audiation. So, what proportion of improvised musical output requires audiation and how sensitive is this to context? In order to make progress in addressing these questions experimentally, a cognitive-scientific frame of reference is required (Goldman, 2013).

A cognitive-scientific approach

Pressing (1988) proposed a cognitive model of improvisation in which musical output is seen as a series of 'event clusters', each comprising a group of notes preformed via the triggering of a stored motor program. Action monitoring occurs through the use of both feedback and feedforward mechanisms. Recent studies have offered some support for this model (for a review, see Beaty, 2015).

Furthermore, the theoretical perspective of common coding paradigms, such as the Theory of Event Coding (Hommel, 2009) offers a coherent and evidence based explanatory framework within which the instantiation of Pressing's model can be situated. From the common coding perspective, actions share neural codes with their intended perceptual consequences and this is consistent with improvisers having an aural image of phrases they play.

Action control is achieved by anticipation of the sensory consequences of motor programs once selected (forward model) or these programs can be selected on the basis of the intended sensory consequences (inverse models). Together with the use of auditory feedback for error correction, these mechanisms constitute the feedback and feedforward aspects of Pressing's model. These mechanisms are not mutually exclusive and their relative importance in the improvisation process bears on the questions posed regarding the role of audiation.

Tonal Working Memory

Another important theoretical perspective involves the role of working memory (WM) in audiation. In addition to the phonological loop component of WM proposed by Baddeley and Hitch (1974), recent studies have found evidence that musicians use a 'tonal loop' for the processing of non-verbal auditory imagery (Schulze & Koelsch, 2012; Schulze, Zysset, Mueller, Friederici, & Koelsch, 2011; Yu et al., 2015). Some of the brain areas involved (for example Broca's area and the premotor cortex) are hypothesized to have a role in the planning and control of actions (Schulze et al., 2011) and this is consistent with brain plasticity in musicians facilitating sensorimotor coupling through practice.

These theoretical perspectives suggest two experimental approaches that could make progress in elucidating the role of audiation in improvisation.

Methods

The first approach involves the use of altered auditory feedback (AAF) in conjunction with electroencephalography (EEG). This approach has been used to investigate action control in musicians (Lutz, Puorger, Cheetham, & Jancke, 2013; Maidhof, Vavatzanidis, Prinz, Rieger, & Koelsch, 2010; Pfordresher, Mantell, Brown, Zivadinov, & Cox, 2014), but this author is not aware of any studies which have used it in the context of improvisation.

In the proposed study, participants would be required to improvise monophonically to a backing track. The auditory feedback would be subject to pitch manipulations and EEG data captured. The hypothesis is that a feedback related-negativity FRN would be elicited at about 250ms (Lutz et al., 2013) only in the presence of accurate audiation of what participants improvise. The musical conditions such as tempo and harmonic complexity of the backing, as well as the nature of pitch manipulations could then be varied.

The second approach uses a blocking paradigm (Brodsky et al., 2008). Participants will be required to improvise normally and also under interference conditions designed to either use the resources of tonal working memory (humming a familiar tune), or to use different resources while representing a similar cognitive loading (e.g. reciting digits). The hypothesis is that tonal working memory is required for audiation. If the nature of the improvisations produced were to differ significantly when the use of tonal working memory is blocked, this

would give support for the use of audiation during improvisation. Quantitative measures such as entropy and pitch class distribution (Goldman, 2013) and qualitative measures such as expert rating could be used to assess musical output.

Results

At the time of writing there are no results available as the experiments are still being developed.

References

Baddeley, A. D., & Hitch, G. (1974). Working memory. *The psychology of learning and motivation, 8*, 47-89.

Beaty, R. E. (2015). The neuroscience of musical improvisation. *Neuroscience and Biobehavioral Reviews, 51*, 108-117. doi:10.1016/j.neubiorev.2015.01.004

Brodsky, W., Kessler, Y., Rubinstein, B. S., Ginsborg, J., & Henik, A. (2008). The mental representation of music notation: notational audiation. *J Exp Psychol Hum Percept Perform, 34*(2), 427-445. doi:10.1037/0096-1523.34.2.427

Donnay, G. F., Rankin, S. K., Lopez-Gonzalez, M., Jiradejvong, P., & Limb, C. J. (2014). Neural Substrates of Interactive Musical Improvisation: An fMRI Study of 'Trading Fours' in Jazz. *PLoS One, 9*(2). doi:10.1371/journal.pone.0088665

Goldman, A. (2013). Towards a Cognitive-Scientific Research Program for Improvisation: Theory and an Experiment. *Psychomusicology: Music, Mind & Brain, 23*(4), 210-221.

Gordon, E. E. (1979). Developmental music aptitude as measured by the Primary Measures of Music Audiation. *Psychology of Music, 7*(1), 42-49.

Hargreaves, W. (2012). Generating ideas in jazz improvisation: Where theory meets practice. *International journal of music education, 30*(4), 354-367. doi:10.1177/0255761412459164

Hommel, B. (2009). Action control according to TEC (theory of event coding). *Psychological Research PRPF, 73*(4), 512-526.

Limb, C. J., & Braun, A. R. (2008). Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. *PLoS One, 3*(2). doi:10.1371/journal.pone.0001679

Lutz, K., Puorger, R., Cheetham, M., & Jancke, L. (2013). Development of ERN together with an internal model of audio-motor associations. *Frontiers in Human Neuroscience, 7*.

Maidhof, C., Vavatzanidis, N., Prinz, W., Rieger, M., & Koelsch, S. (2010). Processing expectancy violations during music performance and perception: an ERP study. *Journal of cognitive neuroscience, 22*(10), 2401-2413.

Norgaard, M. (2011). Descriptions of Improvisational Thinking by Artist-Level Jazz Musicians. *Journal of Research in Music Education, 59*(2), 109-127. doi:10.1177/0022429411405669

Norgaard, M. (2014). How Jazz Musicians Improvise: The Central Role of Auditory and Motor Patterns. *Music Perception: An Interdisciplinary Journal, 31*(3), 271-287.

Norgaard, M., Spencer, J., & Montiel, M. (2013). Testing Cognitive Theories by Creating a Pattern-Based Probabilistic Algorithm for Melody and Rhythm in Jazz Improvisation. *Psychomusicology: Music, Mind & Brain, 23*(4), 243-254.

Pachet, F. (2012). Musical virtuosity and creativity *Computers and creativity* (pp. 115-146): Springer.

Pfordresher, P. Q., Mantell, J. T., Brown, S., Zivadinov, R., & Cox, J. L. (2014). Brain responses to altered auditory feedback during musical keyboard production: an fMRI study. *Brain Research, 1556*, 28-37.

Pressing, J. (1988). Improvisation: methods and models. *John A. Sloboda (Hg.): Generative processes in music, Oxford*, 129-178.

Schaefer, R. S., Desain, P., & Farquhar, J. (2013). Shared processing of perception and imagery of music in decomposed EEG. *Neuroimage, 70*, 317-326.

Schulze, K., & Koelsch, S. (2012). Working memory for speech and music *Neurosciences and Music Iv: Learning and Memory* (Vol. 1252, pp. 229-236).

Schulze, K., Zysset, S., Mueller, K., Friederici, A. D., & Koelsch, S. (2011). Neuroarchitecture of Verbal and Tonal Working Memory in Nonmusicians and Musicians. *Human Brain Mapping, 32*(5), 771-783. doi:10.1002/hbm.21060

Yu, L., Li, X., Yu, H., Cui, Z., Liao, W., Li, S., . . . Wang, Z. (2015). Musicians have larger memory spans for Mandarin tones but not segments. *Psychology of Music*. doi:10.1177/0305735615608695

Zatorre, R. J., & Halpern, A. R. (2005). Mental concerts: Musical imagery and auditory cortex. *Neuron, 47*(1), 9-12. doi:10.1016/j.neuron.2005.06.013