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The improvisatory approach to classical music performance: An empirical investigation into its characteristics and impact

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ABSTRACT: This paper explores the characteristics and impacts of adopting an improvisatory approach to the performance of classical chamber music. Improvisatory approaches to the classical repertoire, once widespread, are now rare in contemporary professional performance practice and so there are few opportunities to study it. This study attempts to fill a gap in knowledge by obtaining data during a live professional concert performed by a chamber trio. Each of five pieces was performed twice, with and without the adoption of an improvisatory approach. The contrasting timing and dynamic features of the two performances were analysed, differential audience response was measured by questionnaire, and synchronised comparative EEG analyses were undertaken on data from all three performers and two audience members. Audience members rated the improvised performances more improvisatory in character, more innovative in approach, more emotionally engaging, more musically convincing, and more risk-taking than the non-improvised (regular) performance. During the improvised performances, the musicians showed less activity in cortical areas associated with sustained attention and more activation of motivational areas and areas related to free will as well as planning and coordination of movements. The improvised performances resulted in greater activation of areas for motor planning in both performers and audience members. Improvised performances were characterised by a larger tactus and a more coherent phrase structure than the regular performances, which displayed a regular and somewhat rigid short-term pulse. The data provide *prima facie* evidence that improvised performances of the classical repertoire can heighten musical quality and audience engagement.

KEY WORDS: classical improvisation, EEG measurement, performance analysis, audience response

Classical improvisation today

Improvisation is rarely associated with western contemporary classical music making, either in terms of educational curricula or mainstream classical music performance (Creech, 2008). Indeed, classical musicians often report anxiety and/or uncertainty when faced with the prospect of improvising (Alter, 2008). However, improvisation has played a pivotal role in the education and practice of many of the most commonly performed classical composers, many of whom were known to their contemporaries as great improvisers. Composers such as Bach, Mozart, Beethoven, Liszt and Chopin were known to showcase their musical virtuosity by producing works spontaneously in performance (Eigeldinger, 1986; Hamilton, 2008). This practice was associated with a substantial body of improvisation pedagogy to be found in historical treatises (Corri, 1810; Czerny, 1983/1836, 1840; Bach, C.P.E., 1949/1753, 1949/1962) and supported a lively tradition that survived into the early twentieth century, as evidenced by improvisatory practices found in early recordings (Leech-Wilkinson, 2010a), which illuminate not only the creation of impromptu musical works, but also an improvisatory approach to notated music (Hamilton, 2008).

It is this ‘improvisatory approach’ that constitutes the main focus of this paper, and extends the definition of improvisation beyond that commonly used in most other research and practice. In conventional discourse regarding performance practice a distinction is normally made between the performance of composed music on the one hand and improvisation on the other, where improvisation is characterised as the spontaneous generation of newly created music, comprising novel notes, motives, rhythms, harmonies – in the tonal context – and musical structures. We extend the scope of the concept of improvisation to include spontaneous changes to all performance-related parameters, even in composed music where all or most of the actual notes played are not altered. Such changes are to be differentiated from those found in the more commonly described ‘expressive performance’ in that the musician’s departure point and frame of mind are such that he or she takes an improvisatory approach, manifested by novel and spontaneous gestures throughout the performance.

This larger definition allows us to treat free improvisation and the improvisatory performance of composed music as points along a continuum. Classical musicians who return to the tradition of enlivening supposedly concrete works through spontaneity and flexibility in every performance can be described as taking an improvisatory approach to composed music. In these cases, improvisation may be represented by an enhanced level of spontaneity at the level of 'How,' and not only (or even predominantly) by means of extemporising new notes ('What,' see for instance Dolan, 2005). The 'How' level refers to aspects of performance such as timing, dynamics, timbre, accentuation and balance between lines in an ensemble.

Such variations have been documented in contemporary accounts of the performances of Chopin and Liszt (as reported, for instance, in Eigeldinger, 1986; Hamilton, 2008). These accounts suggest that the two composers would never have performed the same piece in the same way twice; they would replace previously written passages with freshly improvised ones and make spontaneous changes to the aspects of performance listed above. The role of improvisation in performance thus enabled risk-taking and the possibility of indefinite novelty in the moment, unplanned and left entirely to real-time within-performance decision-making. Both Chopin and Liszt strongly encouraged their students to approach performance in just this way, seeing the improvisatory approach as integral to being a complete performer.

There are few contemporary examples of this approach, but it is manifest in the performance practice of artists such as Robert Levin (Berkowitz, 2010, pp. 121-130; Levin, 2009) who improvises by ornamenting or colouring composed passages and extemporising novel fermata points, *eingangs*, cadenzas and other passages. Levin uses basic strategies and inherent musical forms prepared in the course of both short- and long-term pre-planning and extensive practice (Berkowitz, 2010) but leaves the final decision-making to the last moment. Other performers who employ a similar approach include Dolan (1994), Lancaster (2010), Sivan (2013) and de Jong (2012). Thus we can see a qualitative continuity between Chopin, Liszt and these (very few) contemporary improvising performers' approaches. All have basic plans that are renegotiated in real time during performance, producing unique musical outcomes on every occasion.

Historical accounts, many of which pre-date the advent of recording, can only offer – at most – tantalizing pointers to the nature and impact of improvisatory performance practice. Contemporary empirical studies are required to explore and more rigorously characterise the parameters and effects of improvisatory performances.

Classical improvisation has not been a major focus of contemporary empirical investigations, probably precisely because of its rarity in contemporary practice. However there is some relevant literature that relates to three major topics: the objective dimensions along which performances differ from one another; the effects on listeners/audiences of variations between different performances; and the effects of being involved in improvisation on the performer's experience and awareness. We review the literature on each of these topics in turn.

Objective dimensions

A significant body of published research exists that compares different recorded performances of individual composed classical works, analysing professional recordings available in the public domain to reveal, for instance, historical trends in performance practice. In recent years it has become commonplace for these analyses to be assisted by computer software, allowing greater accuracy and objectivity in the characterisation of expressive methods used, including a wide variety of time- and pitch-based musical features (see Cook, Clarke, Leech-Wilkinson, & Rink, 2009, for a review). Some studies have documented the interpretational development of individual performers by undertaking longitudinal studies of the recordings of the same piece of music made at different times (Cook, 2007). Other studies have compared different performers' interpretations of the same pieces (Repp, 1990, 1992). A major feature revealed by such studies is a tendency towards homogeneity amongst modern recorded interpretations of mainstream classical works, which suggests a relative lack of the application of an improvisatory approach, at least in the recording studio (Philip, 2004).

Even where some recorded professional performances studied might have been expected to contain elements of an improvisatory approach, these have not generally been an explicit focus of the investigation. For example Fabian and Schubert (2009) compared the effects on listeners of three different commercially available recorded performances of a Bach Partita for solo violin, some of which are likely to have included improvised material such as ornamentation and embellishment. However, the descriptions of these performances provided by the authors did not identify the differential use of such embellishments, and therefore their nature and contribution to listener experience remains unknown.

A different approach to comparative performance analysis has been taken by some experimental psychologists who have brought professional musicians into the laboratory and asked them to provide performances of the same musical materials, expressive in different ways, often with little prior preparation, thus potentially encouraging an improvisatory approach. For instance, Vieillard, Roy and Peretz (2012) asked performers to play the same piece of music in three different modes, 'mechanical', 'with expression' and 'with too much expression'. However, this study used short experimenter-generated fragments of music, and the evaluation of differences between performances was confined to calculations of gross averages of parameters such as tempo and dynamics. This analytic approach yielded rather minor differences between the performances, which could indicate – among other things – that the performers in this study were not accomplished practitioners of an improvisatory approach. Also, it is possible that many critical differences between differently expressive performances are not so much at the overall level of a parameter such as tempo or dynamics as in its distribution over time, linked to structural features (as demonstrated, for instance, by Sloboda & Lehmann, 2001).

Additionally, many psychological studies of variation in performance focus less on differences in musicologically-informed effects, and more on the capacity of different performances to communicate different specific (usually basic) emotions (see Juslin, Sloboda & Gabrielsson, 2012, pp. 595-598 for a table summarising the performance features discovered to be associated with the five basic emotions of happiness, sadness, anger, fear, and tenderness). These studies demonstrate the wide variety of parameters that are capable of being deployed by performing musicians when asked to provide performances of the same piece that are expressive in different ways. They do not, however, shed light on how they may be deployed specifically when the intention is to apply an improvisatory approach.

Effects on listeners/audiences

Historical accounts of classical improvisers have sometimes contained eyewitness reports of the effects and impacts of improvised performances on audiences. For instance Eigeldinger quotes remarks made by Sir Charles Hallé on attending a concert in which Chopin improvised:

> “In listening to him you lost all power of analysis; you did not for a moment think how perfect was his execution of this or that difficulty; you listened, as it were, to the improvisation of a poem, and were under the charm as long as it lasted” (Hallé, 1896, quoted by Eigeldinger, 1986, p. 31).

These remarks suggest a particularly compelling quality that absorbed the listener and captured his imagination. Other observations speak more to the musical and structural convincingness of the improvisation, as in this remark by Sir George Macfarren on hearing an improvisation of Mendelssohn:

> “It was," said Macfarren "as fluent and well planned as a written work, and the themes, whether borrowed or invented were not merely brought together but contrapuntally worked (Grove, 1882, p. 300).

In the present age, similar audience responses have been described by Berkowitz (2010) when discussing the improvisations of the contemporary classical pianist Robert Levin. For instance, he reports Richard Dyer, music critic, as saying

> His improvisation of cadenzas showed extraordinary daring; his solo ravings In the fourth concerto first movement cadenza reached such a level of brilliant madness that it seemed as if Beethoven himself were seated at the keyboard (Berkowitz, 2010, p. xiii).

However, anecdotes such as these are indicative at best. They do not substitute for detailed empirical investigation into audience response using rigorous methodologies. There are no studies known to us that directly compare listeners’ responses to improvised and non-improvised (‘regular’) performances of the same piece. However, some studies have compared listeners’ responses to recorded performances of the same music that vary in expressive intent. For example, in the study by Vieillard et al. (2012) mentioned above, listeners’ average ratings for the ‘expressive’ performances of a given sequence indicated that they were perceived as more expressive and more stimulating than the ‘mechanical’ performances of the same sequence. However, listeners were not asked to specify or elaborate on which aspects of the performances informed their ratings.

Very few studies have attempted to investigate the impact on traditional concert audiences of listening to live performances of classical music that vary in their expressive intent. Some studies have measured the subjective responses of audience members via questionnaires and/or interviews (Dobson, 2008; Pitts, 2005; Pitts & Spencer 2007; Thompson, 2006, 2007), but none of them directly addresses responses to the improvised or spontaneous elements of the performance. Neither, as far as we are aware, have there been any studies measuring activity in the brains of individuals listening to improvised music.

Effects on the performer’s experience / awareness

Most empirical work on performers’ experiences of improvising has involved the jazz genre, for the unsurprising reason that jazz is the locus of the largest number of contemporary improvisers.

Neurological studies investigating brain activity in the context of musical improvisation have tended to place performers in fMRI and PET scanners (Bengtsson, Csíkszentmihályi, &

Ullén, 2007; Berkowitz & Ansari, 2008, 2010; de Manzano & Ullén, 2012a, 2012b; Limb & Braun, 2008). Such studies require musicians to perform in highly non-naturalistic settings that are physically constraining, and also preclude audience and/or between-performer interaction. Nevertheless, their findings suggest some important differences in brain activation between improvised and regular performance. For example, Limb and Braun (2008) found that improvisation was characterized by a dissociated pattern of activity in the prefrontal cortex along with extensive deactivation of dorsolateral prefrontal and lateral orbital regions with focal activation of the medial prefrontal (frontal polar) cortex. They argue that such a pattern "may reflect a combination of psychological processes required for spontaneous improvisation, in which internally motivated, stimulus-independent behaviours unfold in the absence of central processes that typically mediate self-monitoring and conscious volitional control of ongoing performance" (Limb & Braun, 2008, p. 1).

In relation to social psychological effects on performers, research on group creativity (Sawyer, 1992, 1999), or 'empathetic creativity' as suggested by Seddon (2005) and Seddon & Biasutti (2009), suggests that group improvisation in different genres is supported by increased levels of attunement between performers. Similar effects have also been found in the contexts of music therapy (Gilboa, Bodner & Amir, 2006) and music education (Beegle, 2010).

The current study

Our specific concern in this article is to understand more about the characteristics of performances of composed repertoire when an improvisatory approach is adopted, and explore the psychological and neurological effects of such performances on performers and listeners in a live performance context.

Based on the considerations above we posed the following research questions:

1. Are there systematic differences between prepared and improvised performance in (a) measurable performance characteristics (changes over time of durations, dynamics, timbre and the inter-relations between them); (b) subjective audience responses (ratings and verbal descriptions); (c) objective responses of both performers and audience members measured by electroencephalographic (EEG) evidence?
2. Do these differences suggest a heightened response to improvised performances?

Differences in performances can be explored and analysed through musicologically informed analysis of performance data using specialist analytic software and intensive listening and viewing of video recordings. The pre-conscious responses of both performers and audience members can be monitored through the use of brain measurement in addition to verbal reports. In contrast to previous studies using fMRI, this study obtained EEG data. Unlike fMRI, the technology for EEG data collection is such that it allows relatively free movement of musicians while playing, and the data can be collected unobtrusively in a naturalistic performance setting. The use of EEG data also provides the opportunity to examine moment-to-moment changes in the responses of both performers and listeners simultaneously, with high temporal resolution, whereas verbal reports can be collected only at the end the performance of a work and are therefore both retrospective and summative. This approach, combining the three different disciplines of psychology, neuroscience, and music performance analysis in a single study, is – to our knowledge – the first time that such an approach has been applied in the study of classical music improvisation, and represents a new method of investigation.

METHOD

Participants

Performers

The performers were members of a professional chamber music trio (flute, viola, harp). All three performers had taken intensive courses, both individually and as a group, in classical improvisation and its applications to the performance of classical repertoire. These courses (taught by the first author) extended over four years.

The courses integrate historical approaches with modern strategies, where students are taught to improvise in both individual and group contexts, across a variety of stylistic languages and forms. Whilst a significant portion of the coursework is devoted to the creation of novel material based on forms such as preludes, baroque dances, rondos, classical sonata form, and generic ABA forms, it is equally focused on developing an improvisatory approach to repertoire that the students are already working on. An immersion in improvisatory practice is thus encouraged to seep into music-making in general.

This approach is a novel application of a Schenkerian concept that is both a re-engagement with creative practice and highlights Schenker's enthusiasm for improvisation (Rink, 1993). Schenker suggested that the composer's awareness of the inner plan of a work allowed for a lucid realization of middle and foreground structures (Schenker, 1979). This method encourages students to engage with this proposed compositional mindset, allowing them to challenge the perceived fixity of a work, opening it to reinterpretation without departing from the composer's materials and language. Further, they are encouraged to utilize their intuitive feeling of the work's directionality to influence the way in which they perform, creating a fusion between intuitive and learned skills.

Audience

The audience comprised 14 individuals, a mixture of students and staff from UK academic institutions, as well as outside guests and casual concert-goers. Among them were two of the authors of this paper who were attached to EEG sensors. All members of the audience were invited, in addition, to provide verbal responses via a questionnaire.

Procedure

The experiment took the form of a live concert on 30 March, 2012, with an invited audience in a large studio regularly used for chamber music performance at the institution where two of the authors work, comprising a somewhat naturalistic setting. Prior to the start of the performance, each audience member was given a questionnaire to fill in during the concert. The audience was briefed by one of the researchers that they were about to hear five pairs of trio performances that would involve some elements of improvisation.

The concert consisted of five different musical items: three short movements from the composed classical repertoire and two group improvisations. Each item was performed twice: once in an improvised mode, and another time in a prepared mode, where the performers were asked to perform convincingly but without taking risks. The prepared version was likened to the type of performance usually given at an international competition. The order of the prepared and improvised performances was randomly varied from item to item, and this order was known only to the performers and one of the authors, who did not participate in the study as a listener.

The programme order was as follows:

1. Ibert: *Andante espressivo* from *Interlude* for flute, viola and harp (prepared mode followed by improvised mode)
2. Telemann: 3rd movement, *Adagio*, from the Trio Sonata in G minor TWV 42:g7 (improvised mode followed by prepared mode)
3. Group improvisation: semi-tonal in ABA form (improvised mode followed by prepared mode)
4. Ravel: Minuet from the *Sonatine* for piano, arranged for flute, viola and harp by Salzedo (prepared mode followed by improvised mode)
5. Group improvisation: tonal, in ABA form (prepared mode followed by improvised mode.

After each pair of linked performances members of the audience were given a short time to rate the two performances for the degree to which they detected or experienced five qualities in them: improvisatory in character, innovative in approach, emotionally engaging, musically convincing, and risk-taking. Responses were made using a six-point Likert scale, ranging from 'not at all/ none' to 'totally/completely'. There was also a space in the questionnaire for free written comments on each performance.

The three performers and two members of the audience were connected to EEG sensors. The performers had been involved in earlier trialling and development of the method, and the precise technical configuration had been improved on the basis of their prior comments to minimise distractions from their normal mode of playing.

Technical details of EEG measurements

Data acquisition

The electrical brain activity of all three musicians and two listeners, was measured by a CE-certified EEG device (Brainmarker, the Netherlands) at the following locations: frontal cortex (F3, F4), central cortex (C3, C4), temporal cortex (T7, T8), parietal cortex (P3, P4) and occipital cortex (O1, O2), all localized according to the international 10-20 system (Jasper, 1958). Ag/AgCl electrodes with carbon shielded wires (Temec, the Netherlands) and conductive electrode gel (Ten20, D.O. Weaver & Co) were used to minimise movement artefacts. Data acquisition was carried out with a sample frequency of 250 Hz. Data filtering was executed using a first order 0.16 Hz high pass filter and 59 Hz fourth order low pass filter. All five amplifiers were time-synchronized using a customized external trigger. Before the measurement the skin was cleaned using abrasive gel (NuPrep, D.O. Weaver & Co.) to ensure low skin impedance (<10 kΩ) and high signal quality.

Data analysis

After each measurement, raw EEG data files were stored and analysed further using

Standardized Low Resolution Electromagnetic Tomography (sLORETA; Pascual-Marqui, 2002). Using sLORETA, the cortical sources of certain brain waves are estimated based on the input from the different scalp electrodes (cortical electrical current density; Cannon, 2012). SLORETA has a better temporal resolution than fMRI, for example, which makes it an appropriate tool for studying state changes in the brain related to musical performance. Like fMRI, multiple epochs can be used to calculate average values of brain waves for different cortical areas.

The sLORETA analysis consisted of several steps: first, every EEG file was segmented in 1 second epochs. The total numbers of epochs, electrodes used and the rate of sampling were used to calculate the EEG cross-spectra of every participant (Cannon, 2012). The cross-spectra were calculated for distinct EEG frequency bands as commonly used in neurology (delta, theta, alpha, beta1, beta2, beta3). The final output consisted of statistical maps of cortical sources per frequency band per participant and piece of music. Overall differences in brain activation in response to the two modes of performance, improvised and regular, were measured as follows: the cortical maps for each mode were averaged over all pieces for all players, and over all pieces for all listeners. The modes were then compared first for players and then for listeners using paired t-tests.

The analysis was focused on two frequency bands: the alpha band, traditionally related to cortical inhibition (Mayhew, Ostwald, Porcaro, et al., 2013; Mo, Liu, Huang, & Ding, 2013), and the beta band, related to cortical excitation (Krauss, Fisher, & Kaplan, 2011). Spatial changes in amplitudes of these bands are presented using the Brodmann areas, which are distinct anatomical areas based on cytoskeletal differences of cortical neurons (Brodmann & Garey, 2006; Devlin & Poldrack 2007). Only significant differences ($p < 0.01$) between the two modes are presented.

Technical details of musical analysis

The analysis of recorded performance using computer software such as BeatRoot, Praat and Audacity has become standard practice in empirical musicology (see Marsden, 2009, for an overview). The free and flexible open-source platform Sonic Visualizer (http://www.sonicvisualiser.org/index.html) has particularly wide appeal because the software allows for real-time analysis using the graphic representation of the acoustic features of a recording, as a waveform or as a spectrogram, and the annotation of visually-recognized data. It is possible to clarify relationships within this single application between a variety of musical parameters, as annotation can be undertaken at the level of tempo and dynamic differences, for example, making it particularly useful for the analyses carried out in the present study. Applications for performance research are explained in depth by Cook and Leech-Wilkinson (2009); for more detailed technical information, please see Cannam, Landone and Sandler (2010). Sonic Visualizer has been used by researchers in a variety of ways, often focusing on the expressive performance characteristics of a genre or work across different performers (e.g., Cook, 2007; Dodson, 2011a; Liebman, Orney & Chor, 2012; Sapp, 2007; Volioti, 2012) or different performances of the same work by the same performer (e.g., Dodson, 2011b; Grachten & Widmer, 2009; Leech-Wilkinson, 2010a).

The analyses in the present study are based on intensive listening sessions by the first author, with objective sound measures as represented graphically by the Sonic Visualiser software. One of its many advantages is that it enables immediate informal visual comparisons of the performance features of different recordings (a method used, for instance by Cook, 2011; Dodson, 2012; Ohriner, 2012; and Sung & Fabian, 2011). We follow the example of such authors as Leech-Wilkinson (2010b), Fabian and Ornoy (2012) and Ohriner (2012) by making the recordings of the performances discussed in this section available to readers as PEG-4 files that can be seen and heard using standard video playback programmes such as QuickTime and inspected using Sonic Visualiser.[1]

RESULTS

Questionnaire data

Figure 1 shows the average scores for the rating scales, combined across audience members and performances.

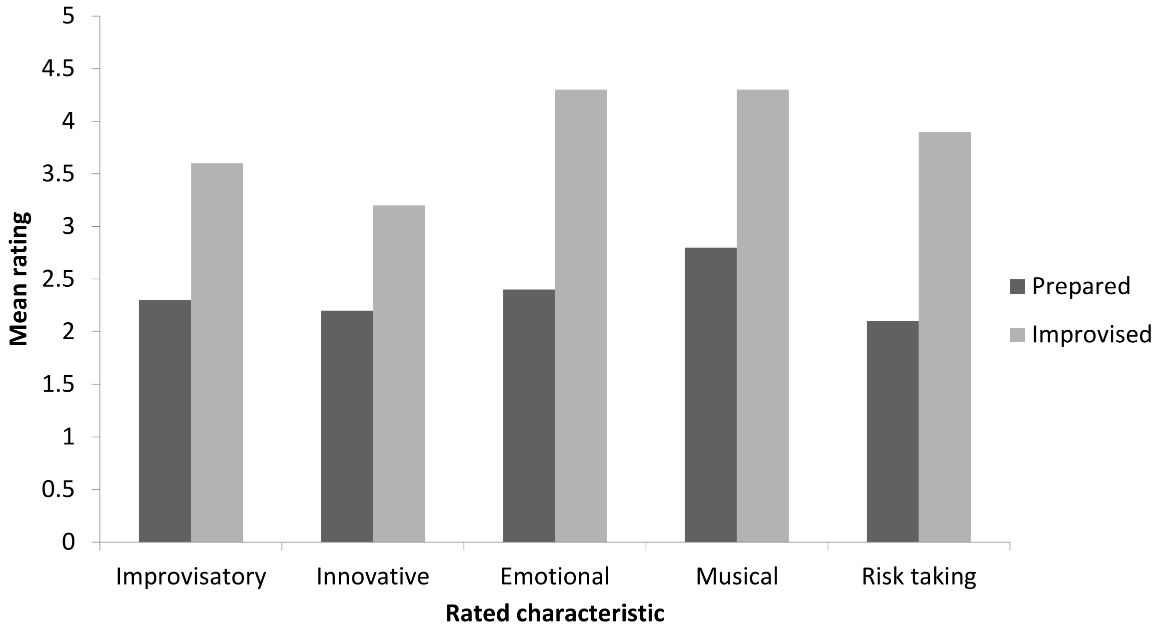

Figure 1. Average scores for the rating scales, combined across audience members and performances.

On every measure, the improvised performance was rated higher than the prepared performance. This was true for every piece on every dimension, a highly consistent effect. Means and standard deviations for ratings on each of the dimensions for each performance are given in Table 1. A three-way analysis of variance (piece, condition, dimension) revealed a highly significant main effect of condition (prepared versus improvised) (F [1,13] = 95.8, $p < 0.0001$). There was a less significant interaction between piece and condition (F [4,52] = 4.88, $p < 0.002$), such that differences between the ratings for improvised and prepared performances were greatest (2.2) for the fifth piece (tonal improvisation) and least (1.0) for the second piece (semi-tonal improvisation). There were intermediate effects for the pieces

[1] If the reader has the opportunity to use Sonic Visualiser, it is possible to listen to the entire performance while viewing the timing and loudness profiles.

composed by Telemann (1.3), Ibert (1.6), and Ravel (1.9). No other two- or three-way interactions approached significance. It is clear that the difference in instructions to the musician manifested itself in strong consciously observable differences in the quality of these performances.

Table 1. Means and standard deviations for each piece, condition and dimension

Piece	Dim. 1	Dim. 2	Dim. 3	Dim. 4	Dim. 5
	Improvisatory	Innovative	Emotional	Musical	Risk-taking
1 prepared	1.79(.40)	2.35 (.40)	2.86 (.33)	3.14 (.33)	1.83 (.31)
1 improvised	2.92 (.41)	3.29 (.26)	4.29 (.30)	4.21 (.24)	3.86 (.21)
2 prepared	1.57 (.36)	1.50 (.36)	2.00 (.35)	2.57 (.34)	1.43 (.29)
2 improvised	3.14 (.38)	3.43 (.38)	4.43 (.20)	4.14 (.28)	3.23 (.29)
3 prepared	3.50 (.39)	3.07 (.34)	2.36 (.37)	2.71 (.35)	3.29 (.38)
3 improvised	3.86 (.32)	3.50 (.34)	4.14 (.25)	4.36 (.30)	4.07 (.22)
4 prepared	2.00 (.38)	1.86 (.34)	2.64 (.41)	2.86 (.33)	1.93 (.37)
4 improvised	3.50 (.33)	3.57 (.36)	4.29 (.24)	4.29 (.19)	3.57 (.32)
5 prepared	2.36 (.39)	2.07 (.35)	2.28 (.38)	2.79 (.33)	1.79 (.40)
5 improvised	4.57 (.25)	4.29 (.24)	4.50 (.23)	4.21 (.32)	4.71 (.19)

Key: 'Diff.' represents the mean difference in rating between the improvised and prepared versions of Piece 1 = Ibert (diff. = 1.3), Piece 2 = Telemann (diff. = 1.9), Piece 3 = Improvisation (semi-tonal) (diff. = 1.0), Piece 4 = Ravel (diff. = 1.6), Piece 5 = Improvisation (tonal) (diff. = 2.2).

Most members of the audience also elaborated on their responses with free verbal comments. Indicative responses from the prepared performances included: "Beautiful piece but lacking in real communication" (Ibert); "Pleasantly played, though tame and conventional" (Ravel); "Completely bland with no memorable components" (Improvisation). By contrast, indicative responses from the improvised performances included: "I thought the first performance moved me until I heard the second. Wow! It could easily have gone too far, but was so beautiful" (Ibert); "Gorgeous freedom and quality of sound" (Telemann); "It was very intense. Musically a lot happened. The musicians were really making music and telling a story together" (Improvisation). These responses suggest that most audience members enjoyed richer and more complex experiences during the improvised performances.

However, this does not mean that every improvised performance was seen as musically more appropriate in every single case. For example, one quite complex response ended by favouring the prepared performance:

> This performance was much more technically convincing than the previous one, there was no dissonance, it flowed, and it showed on the performance itself. It was one of those when you get goosebumps – but – and a huge but – perhaps because of the type of Mahlerian music this was, this actually distracted from the message of the music, I felt. As such, the first one I engaged with more, even though the musicians didn't seem to (Ravel).

Another comment of a similar nature, in response to a prepared performance, was: "I loved the restrained feeling of this; holding back something always" (Ibert). These comments make it clear that aesthetic value can be judged in different ways by different listeners. Nonetheless, in the great majority of cases the verbal comments were such that they were consistent with the numerical ratings, and indicated that in general, the improvised versions were preferred.

EEG data

In order to explore *typical* overall differences between prepared and improvised conditions we calculated mean levels of brain activity averaged over the three players for the five prepared and five improvised performances respectively. The same was done for the two listeners. This calculation was made for two types of brain waves: alpha waves, traditionally associated with cortical inhibition and (fast) beta waves, associated with excitation. Figure 2 shows the average differences between sources of alpha and beta wave activity (left and right panel respectively) across the regions of the players' brains as projected onto the cortical surface.

We used the freeware sLORETA software developed by Roberto D. Pascual-Marqui (Fuchs, Kastner, Wagner et al., 2002; Jurcak, Tsuzuki, & Dan, 2007; Pascual-Marqui, 2002) to visualize the changes in levels of brain activity. The software returns images of the log of F-ratios. Non-statistically significant differences are indicated by grey and significant differences by colours. Coloured regions correspond to significant differences of activation with *p* values of at least 0.05. The red corresponds to the maximally observed increase and blue to the maximal decrease of activation.

Changes in cortical excitation and inhibition are presented using colour maps of cortical activation sources. The most striking results were increased inhibition in Brodmann Area 9 and increased excitation in Brodmann Area 24. Brodmann Area 9 is part of the dorsolateral prefrontal cortex and is actively involved in sustained attention, working memory and inhibition of responses. Brodmann Area 24 is the anterior cingulate gyrus/ventral anterior cingulate cortex and is responsible for motivation and will.

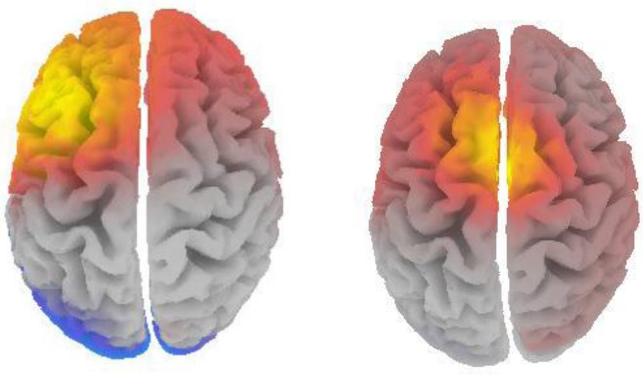

Figure 2. Difference between sources of alpha (left) and beta waves in prepared and improvised modes. Warm, yellow colour signifies a significant difference and grey no significant difference.

Increased inhibition (left figure) was present in Brodmann Area 9, increased activation (right figure) in Brodmann Area 24. Also, a slight but significant decreased inhibition (blue colour) was observed at the left visual cortex (Brodmann Area 19). A similar analysis was made for the EEG data obtained from listeners.

These analyses suggest the musicians, while playing in the improvised mode, exhibit less activity in cortical areas associated with sustained attention and more activity in cortical areas associated with motivation and free will, than while playing in the prepared mode. There was also increased activity in the musicians' cortical areas responsible for planning and coordination of movement, and a slight but significant decrease of inhibition in the left occipital cortex (Brodmann Area 19), possibly related to increased visual processing during improvisation.

By contrast with the performers, the listeners were more actively engaged with the musicians when they were playing in the improvised than in the prepared mode. The improvised mode was associated with more activation of areas responsible for executive functioning, whereas cortical regions associated with self-awareness were less activated. The finding that listeners showed activation of cortical areas in charge of motor planning and execution that were almost identical to the activation patterns of the musicians suggests that listeners seemed to relate more to the movements of the musicians in the improvised mode; likewise, they exhibited increased activation in Brodmann Area 24 during improvisation, as did the musicians. The similarities between the cortical activation patterns of musicians and listeners suggest that that both groups experience correlated cognitive changes during improvisation compared with prepared musical performance.

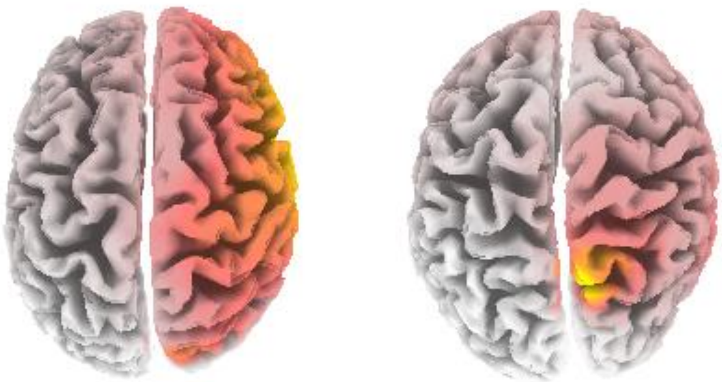

Figure 3. Left panel: Averaged across all improvisation the differences between musicians and listeners are located in the right hemisphere, with the highest value in the right auditory cortex indicating more activation in Brodmann Area 22 for musicians. Right panel: Averaged over special moments only, the small area of the precuneus (Brodmann Area 7, related to visuospatial information processing) shows significantly more activation in musicians than listeners. These results are true for all frequency bands.

The data show that neuronal activity of both players and listeners varied substantially over the time course of each performance. To begin to account for this variation we analysed the EEG response in the same way as described above but restricted to a few temporal windows of particular musical significance as identified through musical analysis. These special moments are: in the Telemann movement, the fourth crotchets of bars 4 and 10, as well as the modulations in bars 6-8 (detailed below in p. 15); and in the Minuet from Ravel's *Sonatine*, bars 51-56 and bar 67. We discuss these moments in the next section. First, we present the results of the sLORETA analysis of EEG data at the special moments only, in comparison with improvised performance overall (Figure 3) and, second, during improvised and non-improvised performance (Figure 4). The comparison shown in Figure 3 was made by subtracting the averaged activation levels of the listeners from the averaged activation levels of the players. The comparison shown in Figure 4 was made by subtracting musicians' averaged activation levels while playing non-improvised performances from their averaged activation levels while playing improvised performances (left panel) and by subtracting listeners' averaged activation levels while hearing non-improvised performances from their averaged activation levels while hearing improvised performances (right panel).

We found that the brain activity of musicians and listeners during improvised performance was more similar at the special moments than improvised performance overall, as shown by the larger region of grey in the right panel of Figure 3 representing significant differences in musicians' and listeners' brain activation in Brodmann Area 7 ($p = 0.03$).[2]

When we compared the brain activity of musicians and listeners during the special moments only, in improvised and non-improvised performances, we found higher levels of activation around Brodmann Area 6, responsible for movement, in both listeners (Figure 4, left panel) and musicians (right panel) during improvisation. We also found lower levels of activation in listeners' (but not musicians') Brodmann Area 19, responsible for visual processing, during improvisation. These findings are clearly only preliminary and we hope to be able to substantiate them in the near future by undertaking further experimental studies.

Figure 4. Average differences of excitation in cortical areas of musicians (left) and listeners (right) during special moments in non-improvised performances subtracted from improvised performances. The yellow and red areas represent increased activation in Brodmann Area 6 comprising the premotor cortex and supplementary motor area, which is responsible for the planning of movements. The blue shading represents decreased activation in Brodmann Area 19, responsible for visual processing.

Musical performance data

We present here a detailed analysis of two of the five pairs of performances, selected to represent different stylistic genres (baroque and impressionist), and because it is relatively straightforward to make a direct comparison between two performances of composed music. The comparison of performances that are both freely improvised requires a different

[2] Note that the musicians made more improvisational gestures at these moments, as shown in the next section of this article.

and more complex approach that will be developed in a future publication. In the present analysis we critically appraise the way the musicians approached the two modes of performance, and highlight the factors we believe to have contributed to the responses and enhanced experiences reported by the audience. We do this in two stages. First we describe some overall characteristics of the performances differentiating between the prepared and improvised versions. Next we analyse specific sections of the performances in detail focusing on the strategies typically adopted by the performers at key expressive moments in the music: the four segments for which analysis of time-specific EEG data was reported in the previous section.

Sonic Visualiser permits the depiction of two profiles simultaneously, synchronised along a fixed time axis: changes in tempo, represented by the upper line in the images that follow, and changes in amplitude (loudness), represented by the lower line. It should be noted that the amplitude curve is not as reliable as the tempo curve and should be considered merely indicative. For full appreciation, the reader is encouraged to read the relevant analysis while listening to and viewing the relevant video recording alongside the associated graph reproduced in the figures below.[1] In each pair of graphs, the upper pair is derived from the prepared performance and the lower from the improvised performance. Contrasts will be drawn between the use of dynamics, timing, and timbre, as well as extemporised notes, and how these were distributed at different levels of the pieces' structure, in order of their appearance in each performance.

Telemann

The score of the slow movement of a trio sonata for two melodic instruments and continuo is presented in Figure 5. It is a canon in free counterpoint written in a typical German, late Baroque, style. Although it is based on one theme and flows as one through-composed line, it is in A B A' form. The A section comprises bars 1-6, the B section (bars 6-9) represents a development, and following A' (bars 9-12) there is a codetta (bars 12-14) or closing phrase elaborating on the material first introduced in bar 3.

We identified a number of special moments of interest in the music that were reflected in the performances:

- On the fourth crotchet of bar 4 at the Neapolitan chord: a lowered second degree in relation to D minor. This is unexpected, since Telemann prepares a cadential moment just before this, comprising the dominant with the leading note C sharp leading to tonic D.
- A similar moment occurs in bar 10 and is equivalent to the first; again, it is on the fourth crotchet, in the context of the movement's G minor tonality.
- Special moments occur also in bars 6-8 where the viola and the flute have two call and response sequences. Bars 6 and 7 modulate from D minor to C minor; next, bars 7 and 8 modulate to B flat major, before returning to G minor. The specific moments of harmonic change in these bars are the third crotchet in bars 6 & 7, and the fourth crotchet in bar 8.


III
Adagio
E♮
F♯
F♮
F♯
B♮
C♯
B♭
F♮
C♮
4
B♮
C♯
B♭
E♭
C♮
C♯
E♮
B♮
C♮
7
B♭
E♭
F♯


9
9
F♮
E♮ F♯ E♭ A♭ F♮
11
F♯
A♮
13
F♮
F♯
C♯
E♮

The vertical lines on the graphs represent the eight quaver beats in each bar, labelled by bar number and beat (e.g. the third quaver in bar 2 is labelled 2.3): this level of representation is required in the analysis of a slow movement such as this if the gestures used by the performers in each mode of performance are to be followed and compared. The prepared performance of the whole movement can be seen and heard in **Audio-Visual 1** and the improvised performance in **Audio-Visual 2**. The prepared performance was played slightly faster (duration: 1'47'') than the improvised one (1'56"). Even though the improvised performance is nine seconds longer, it nevertheless conveys the (subjective) impression of being more 'forward moving' than the prepared performance.

Four general observations can be made: 1) Tempi and dynamics fluctuated to a greater extent in the improvised than the prepared performance. 2) Tempi and dynamics changed with greater periodicity in the improvised than the prepared performance, as did timbre and the interplay between performers, although these features could not be illustrated using Sonic Visualiser. 3) Musicians' choices of gesture were less conventional in the improvised than the prepared performance, which may account for higher ratings on the 'innovative' and 'emotionally engaging' dimensions (see Imberty, 2000, and Cohen & Inbar, 2002, on conventions in musical performance). Finally, the musicians used longer-term local phrasing and achieved a more coherent global structure in the improvised than the prepared performance, which may account for higher ratings on the 'musically convincing' dimension.

As can be both heard in the audio-visual examples and seen in the graphs below, the musicians generally used a crotchet tactus (beat) in the improvised performance but a quaver tactus in the prepared performance; furthermore they often slightly accented the second, fourth, sixth and eighth quavers of the bar, resulting in more rigidly regular and homogenous playing. This is evident from the short-term zigzag tempo curve and frequent accents shown in the amplitude curve (Figure 6a). By contrast, periodicity in the improvised performance was twice as long, enabling larger gestures and more room for the unexpected (Figure 6b). The ways in which the Neapolitan chord was approached in the third crotchet of bar 4 is shown in Figures 7a and 7b, and in the third crotchet of bar 10 in Figures 9a and 9b. The crotchet tactus in the improvised performance provided the time needed for the musicians to accommodate to the unexpected changes in tempo, dynamics and timbre, and the flexibility that enabled them to stay together at these points.

We now focus on some of the moments in the movement at which typical strategies were adopted by the musicians in the two modes of performance, although they subsequently reported not being fully consciously aware at the time of the details revealed by the analysis. The first two bars of the prepared and improvised performances of the movement can be seen and heard in **Audio-Visual 3** and **Audio-Visual 4**. The 'forward movement' heard in the improvised performance can be seen in the shape of the tempo curve in Figure 6b from 1.5 to 2.3, which contrasts with the zigzag shape of the curve in the prepared performance shown in Figure 6a.

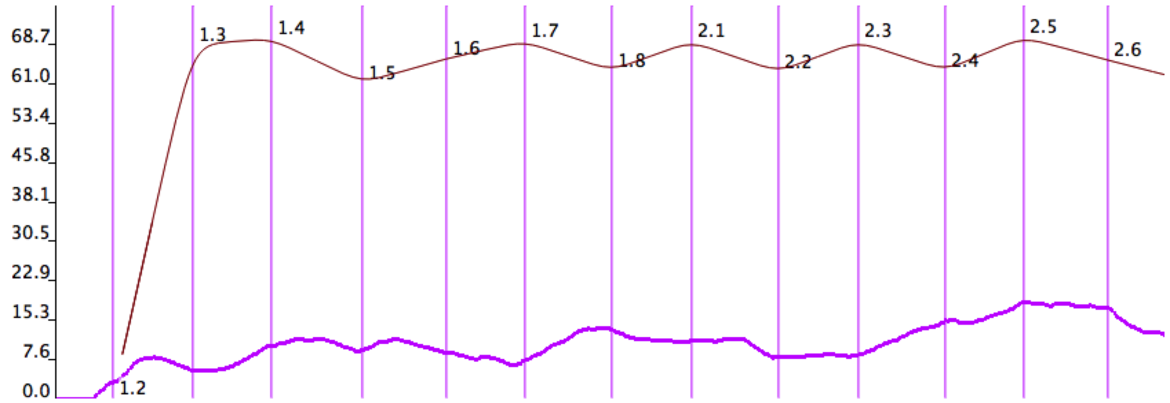

Figure 6a. Prepared performance of Telemann bars 1-2.

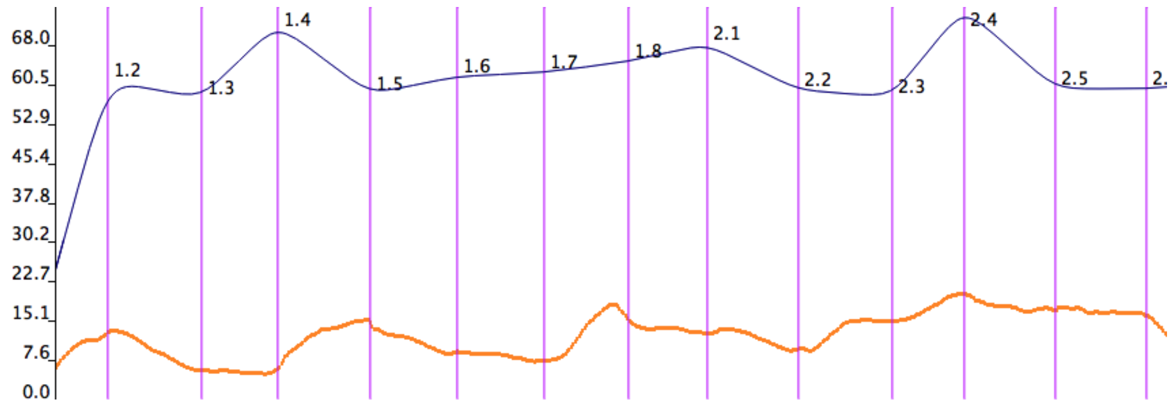

Figure 6b. Improvised performance of Telemann bars 1-2.

The range of tempi was wider (58-76bpm) in the improvised than the prepared mode (61-70bpm) and the dynamics fluctuated more; in the prepared mode an intensity peak creating more rigid short-term regularity can be seen on almost every quaver.

It is evident from the tempo and amplitude curves shown in Figures 7a and 7b that the Neapolitan chord is preceded by a *rallentando* and *diminuendo* in the improvised but not the prepared performance; rather there was a slight increase in the tempo and a crescendo just before the Neapolitan chord in 4.7. The performers demonstrated their creativity when playing in the improvised mode by extemporising; for example, the harpist added a bridging passage in bar 5, resolving the Neapolitan chord to the third degree.

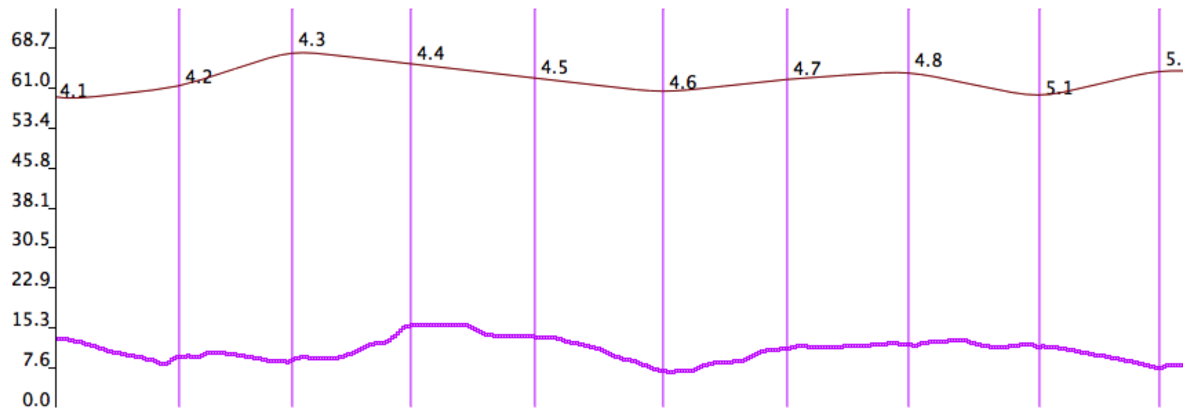

Figure7a. Prepared performance of Telemann bars 4-5.

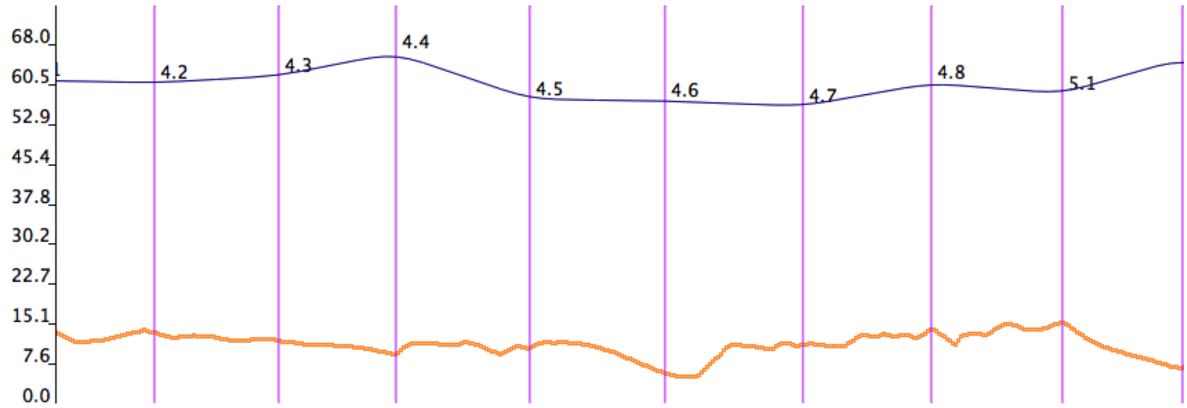

Figure7b. Improvised performance of Telemann bars 4-5.

The two sequences of call and response between the viola and the flute in bars 6-8 can be seen and heard in **Audio-Visual 5** and **Audio-Visual 6** and are illustrated in Figures 8a and 8b.

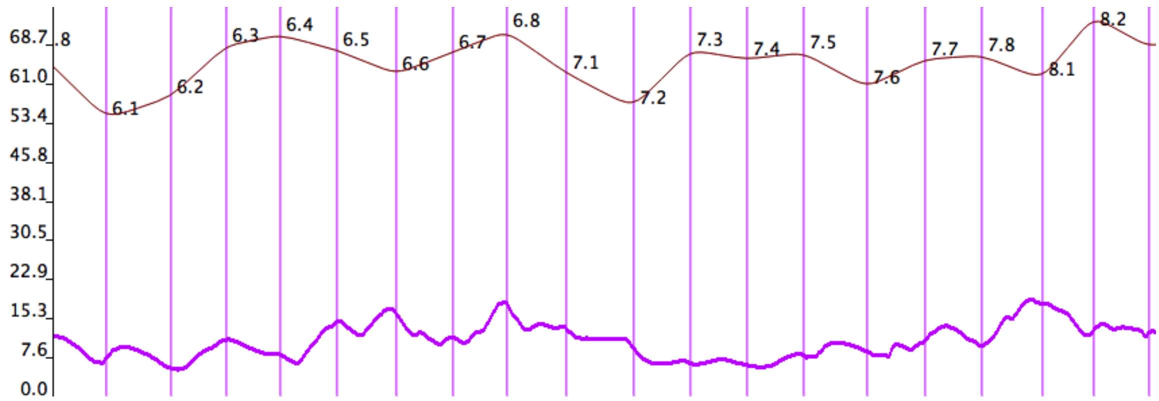

Figure 8a. Prepared performance of Telemann bars 6-8.

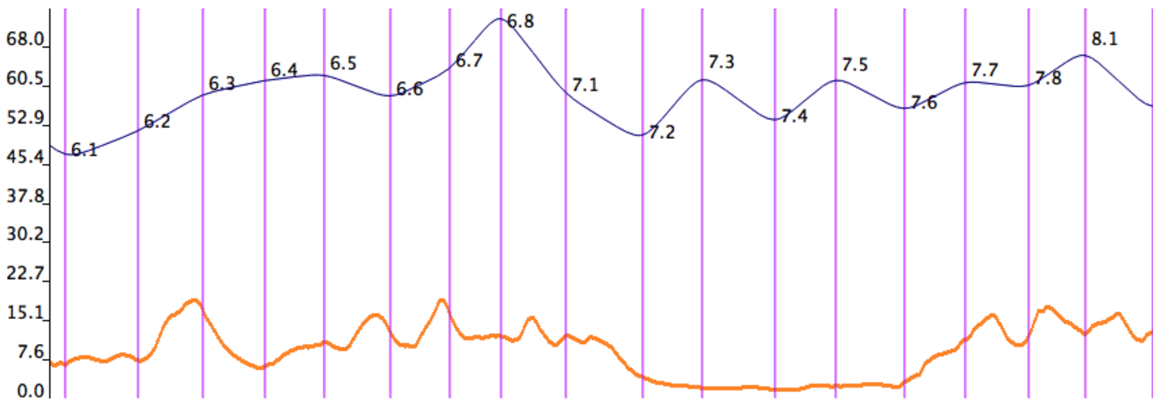

Figure 8b. Improvised performance of Telemann bars 6-8.

Different dynamics and tempi were used in the improvised and prepared performances. The dynamics were more varied in the improvised performance, with an unprepared pianissimo in the second sequence. The two sequences were combined within a single coherent phrase, as illustrated by the long arching shape that can be seen in the tempo curve from bar 6 to the middle of bar 7 in Figure 8b. There was an accelerando throughout bar 6, shared between the flute and viola, towards the climax of the passage where the top F is played by the flute at 6.7, which involved an enhanced level of listening between the performers. After this gesture there was a return in bar 7 to a more consistent tempo. Other points of interest include the lack of correlation between the amplitude and tempo curves for the improvised performance: the dynamic level dropped unexpectedly and remained at a constant pianissimo throughout most of bar 7 whilst the tempo rose and fluctuated. Previous research suggests that performers usually tend to vary tempi and dynamics simultaneously (Repp, 1994; Todd, 1992), so the gesture created at this moment by the musicians playing in the improvised mode contradicted not only learned tendencies, but also what might be thought of as natural tendencies and expectations, and thus made it 'special'. By contrast, the tempi did not fluctuate in the prepared performance according to the phrasing, and the dynamic intensity stayed the same despite the harmonic change. In the improvised performance the flautist filled the major third E flat to G by adding the passing note F before the last beat of bar 7, a gesture supported by his two partners who 'gave him time' within the slow pulse they all shared: a moment involving intense listening and shared risk-taking, most likely felt by the audience and with which they engaged.

Finally we turn to bars 9-12 as seen and heard in **Audio-Visual 7** and **Audio-Visual 8**, and illustrated in Figures 9a and 9b.

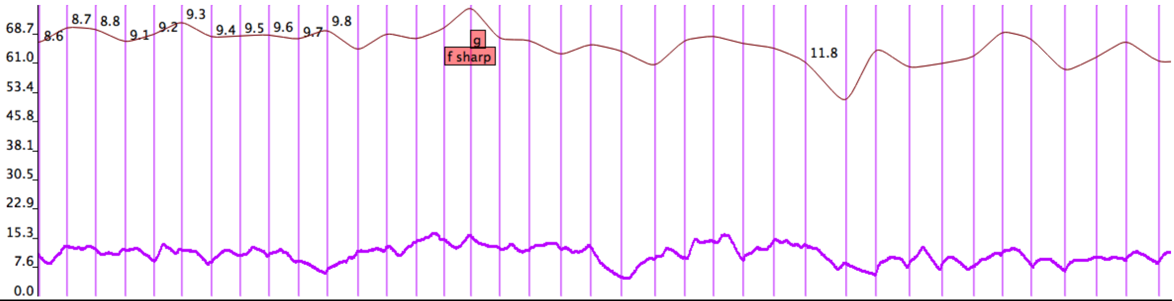

Figure 9a. Prepared performance of Telemann bars 9-12.

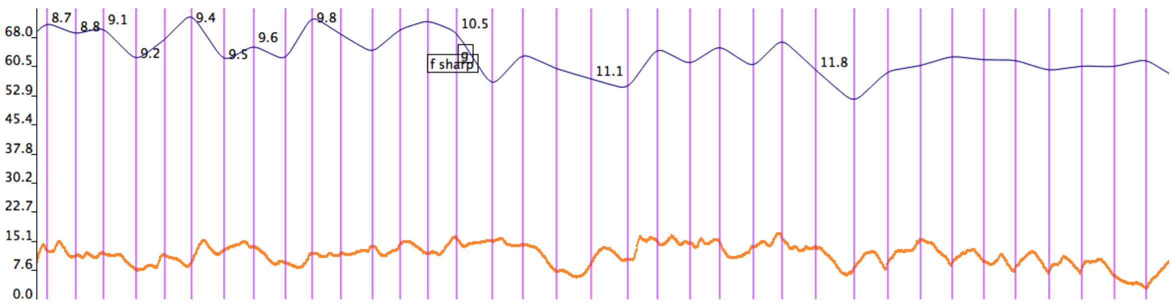

Figure 9b. Improvised performance of Telemann bars 9-12.

The passage leading towards the final tonic cadence in G minor is similar to bar 4, discussed above, with a Neapolitan chord at 10.7. The musicians made the same gesture as before in the improvised performance but in a more pronounced way, adding a sense of unity and making explicit the macro-structure of the movement. There was also a noticeable change in timbre on the flute's long G at the Neapolitan chord in bar 10, where the prolongation of time (5.1 seconds, nearly twice as long as the 2.9 seconds in the prepared performance) was supported by the other players, who slowed rather than speeding up. The phrasing in bar 10, beginning with the flute's upbeat D leading to the top G, was different, too, in the two performances. Whilst there was a gentle but continuous accelerando towards the top G in the prepared performance, representing the tendency already mentioned for musicians to align pitch and tempo, the tempo in the improvised performance decreased between the F sharp at bar 10.4 and the top G at bar 10.5 as the dynamic intensity increased, thus generating a tension to which the flute's change of timbre also contributed.

Ravel

Ravel's strong interest in classical forms is manifested in the *Sonatine* as a whole and in its second movement, shown in Figure 10 (in an arrangement for violin, cello and piano, since for copyright reasons we cannot publish the arrangement for flute, viola and harp used in the study). This Minuet is modal in character, moving between D flat major (Ionian) and F minor (Aeolian) modes. Its form is the same as the Telemann movement: A, the main theme (bars 1-24), B, the middle section in contrasting mood (bars 25-65, bars 51-65 being a closing section of the development); A' (bars 66-90); codetta (bars 91-94. The A theme is 12 bars long, divided into 4 + 3+ 5 bars and repeated immediately.

As for the Telemann movement we identified a number of special moments of interest in the music that were reflected in the performances: first the *stretto* effect in bars 35-47 where Ravel employs progressively shorter phrase lengths (4 bars, then 3 bars, and finally 2 bars); second, bars 51-57, marked *plus lent*, where the harmonic movement stands still on F sharp minor signalling a change of mode from Ionian to Aeolian; third, bars 57-65, which prepare for the reprise of the main theme and a return to the initial tempo. The prepared and improvised performances of the complete Minuet can be seen and heard in **Audio-Visual 9** and **Audio-Visual 10** respectively.

While the differences between the durations of the prepared (2'51") and improvised performances (2'29") are negligible the tempo profiles shown in Figures 11a and 11b are very different. Vertical lines indicate bars. Tempi varied more in the improvised (18-56bpm, the beat lasting a dotted minim – see bar 44) than the prepared version (24-47bpm – see bar 81). The first two phrases of the prepared and improvised performances (bars 1-12 and 13-24) can be seen and heard in **Audio-Visual 11** and **Audio-Visual 12** respectively, and the corresponding tempo and dynamic graphs are shown in Figures 11a and 11b.

The second phrase is a repetition of the first, but the performance of the two phrases was fundamentally different in the prepared and improvised modes. It is evident from the graphs that in the prepared performance the musicians used similar articulation, dynamics and tempo fluctuations in both phrases (other than in bars 2-4), with the tempo peaking in bar 4 both times. The audio-visual example confirms that each phrase was subdivided into two sub-phrases (4+8 bars). By contrast, the repetition of the first phrase in the improvised performance was performed quite differently. There was a burst of energy in the first two bars of the first phrase, and the tempo peaked in the second bar before relaxing continuously until the *rallentando* in bars 9-12, producing two sub-phrases of 2+10 bars. The tempo peaked twice in the second phrase, in bars 16 and 20. Again, the audio-visual example confirms that the second phrase was sub-divided into 3x4 bars.

Sonatina fis-moll

Maurice Ravel (1905)


22
Vno
pp
pp
22
arco
Vc.
pp
p
22
Pfte
p
pp
29
Vno
mp
f
ff
29
Vc.
p
f
ff
29
Pfte
p
f
ff
Ted.
Ted.
rit.
Piú lento
36
Vno
p
36
Vc.
p
rit.
36
Pfte
p


3
accel.
Tempo I
Vno
Vc.
Pfte
pp
(senza rit.)
rit. poco a poco

Figure 10. Minuet from Ravel's *Sonatine*.

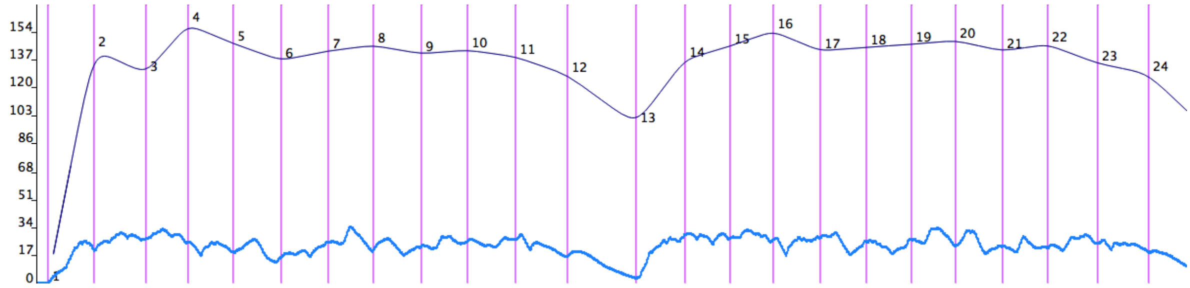

Figure 11a. Prepared performance of Ravel bars 1-24.

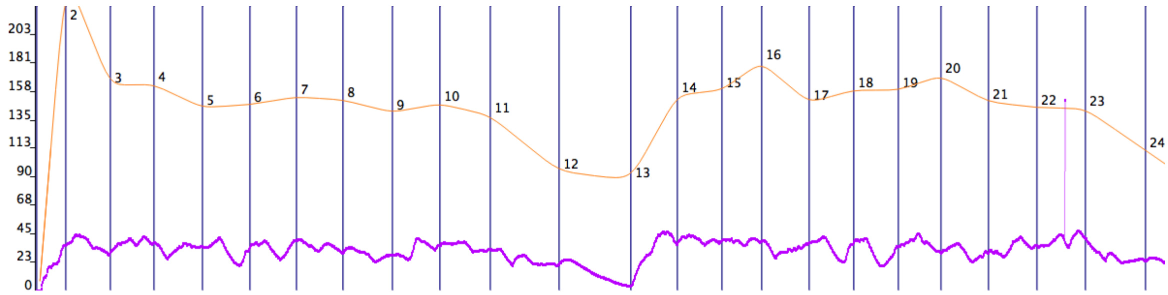

Figure 11b. Improvised performance of Ravel bars 1-24.

The prepared and improvised performances of the middle section of the Minuet (bars 25-51) can be seen and heard in **Audio-Visual 13** and **Audio-Visual 14** respectively, and the corresponding tempo and dynamic graphs are shown in Figures 12a and 12b. This section is a development of the first statement, but while in the prepared performance similar tempi, timbre and dynamics are maintained throughout both sections, they are varied significantly in the improvised performance, creating a sense of organic evolution from the opening of the movement and longer-term directionality.

For example, compare the flute's D flat to A flat ascending fifths in bars 1 and 13, marked piano in the score, with the F to C ascending fifth in bar 25, marked pianissimo. The harmonic contexts are different: D flat major/Ionian mode at the beginning of the movement, and F minor/Aeolian mode in bar 25. In the prepared performance the flautist made no difference between the first two ascending fifths and the third one: each bar lasted exactly 1.4 seconds. In the improvised performance the flautist played the third ascending fifth much slower: bar 13 lasted 1.5 seconds but bar 25 a total of 1.8 seconds; it was played quieter, too, the lower harmonics producing a different timbre. In addition, different articulations were used. The second note of each pair, A flat, was emphasised in bars 1 and 13, whilst in bar 25, both notes – F and C – were articulated equally, creating a *tenuto* or *parlando* gesture.

Similar contrasts between the two performances can be seen later in the movement. In the prepared performance the musicians barely observed the *crescendo/diminuendo* indicated in bars 35-38 of the score, while in the improvised performance they increased both tempo and dynamics towards bar 37 and reduced them again towards bar 39. They played regular crotchets in the prepared performance but a tactus of only one beat per bar when improvising. Phrasing with longer rhythms produced a more coherent flow leading to an effective 'take-off' towards the climax at bars 44-47. Also worth noting is the *stretto* effect starting at bar 35: a four-bar phrase (35-38), two consecutive three-bar phrases (39-

41 and 42-44) and two more bars (45-46) leading to the climax at bars 47-49. The tempo curves in the graphs show the clearer sense of directionality towards the climax in the improvised performance. These are created by more coherent fluctuations of tempi and dynamics than in the prepared performance, in which the same gestures are repeated in the sub-phrases leading to the climax. The amplitude curve, however, does not adequately capture the variations of intensity that are clearly audible in the recording.

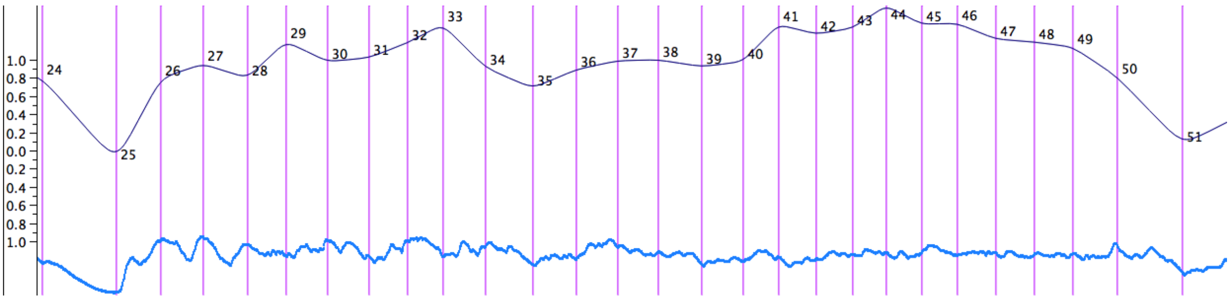

Figure 12a. Prepared performance of Ravel bars 25-51.

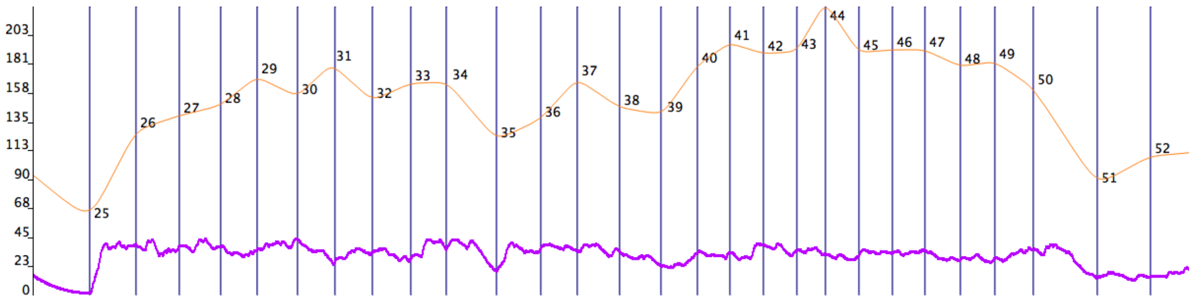

Figure 12b. Improvised performance of Ravel bars 25-51.

The prepared and improvised performances of the end of the development section leading to the reprise (bars 51-76) can be seen and heard in **Audio-Visual 15** and **Audio-Visual 16** respectively, and the corresponding tempo and dynamic graphs are shown in Figures 13a and 13b. Bars 51-54 – "*plus lent*" – include a rare moment of harmonic, dynamic and tempo change before preparing the reprise. In the prepared performance, bars 51-52 and 53-54 sounded nearly the same, played with regular crotchet beats. Because the crotchet beats were not emphasised so much in the improvised performance, and the bars were grouped together, this passage flowed better, bars 53-54 appearing to evolve and differ from bars 51-52. There were also noticeable changes of dynamic – a *crescendo* in the second beat of bar 53 – and tempo, which increased.

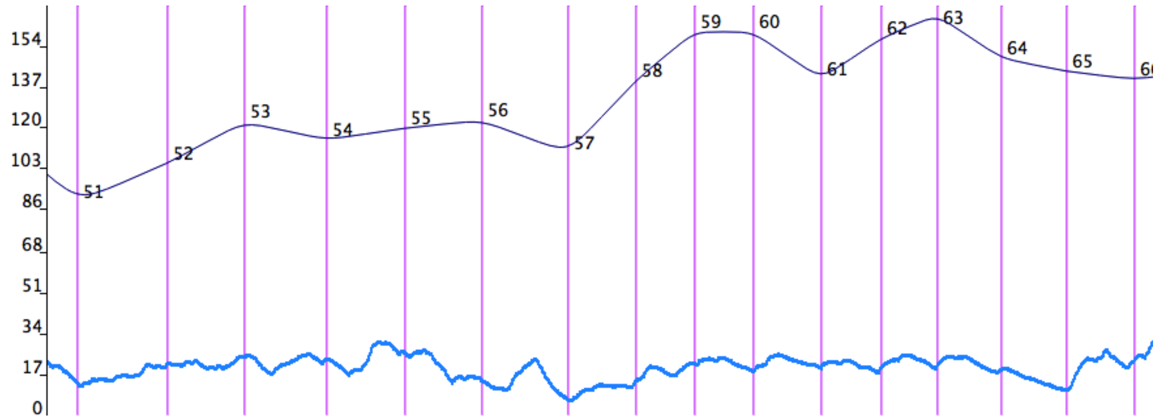

Figure 13a. Prepared performance of Ravel bars 51-65 ("*plus lent*" and "*Reprenez peu à peu*").

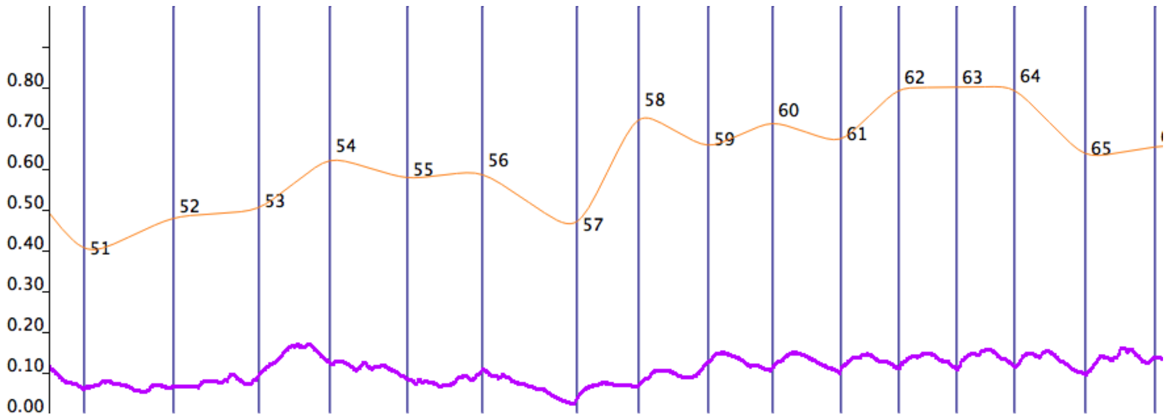

Figure 13b. Improvised performance of Ravel bars 51-65 ("*plus lent*" and "*Reprenez peu à peu*").

The passage from bar 57 leads to the reprise in bar 65. Again, the improvised performance was more coherent than the prepared one because, in the former, bars 57-58 and 59-60 were phrased as sequences, like waves moving backwards and forwards. In the prepared performance the musicians did not return to Tempo 1 at the reprise but rather continued the *rallentando* from bar 63; in the improvised performance they started the *rallentando* at bar 64 before returning to the faster initial tempo in bar 65. This suggests a deeper connection with the structure and better ensemble listening so as to achieve more flexibility and synchrony in performance.

The prepared and improvised performances of the reprise (bars 65-77) can be seen and heard in **Audio-Visual 17** and **Audio-Visual 18** respectively, and the corresponding tempo and dynamic graphs are shown in Figures 14a and 14b. In the prepared performance the reprise consisted of a mere repeat of the opening section. In the improvised performance, the reprise was performed with a new sub-phrasing and articulation as well as extemporised notes: for example, the beginning of bar 67 contained an added appoggiatura and a further extemporised sequence. Also, the tempo and dynamic fluctuations were different from those at the beginning of the movement. The musicians' sense of ongoing change as the work unfolded contributed yet another element to the evolutionary quality of the improvised performance.

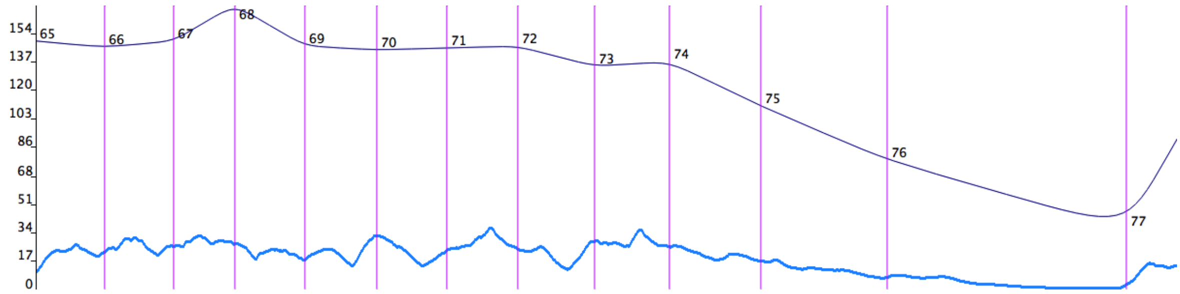

Figure 14a. Prepared performance of Ravel bars 65-77 (reprise).

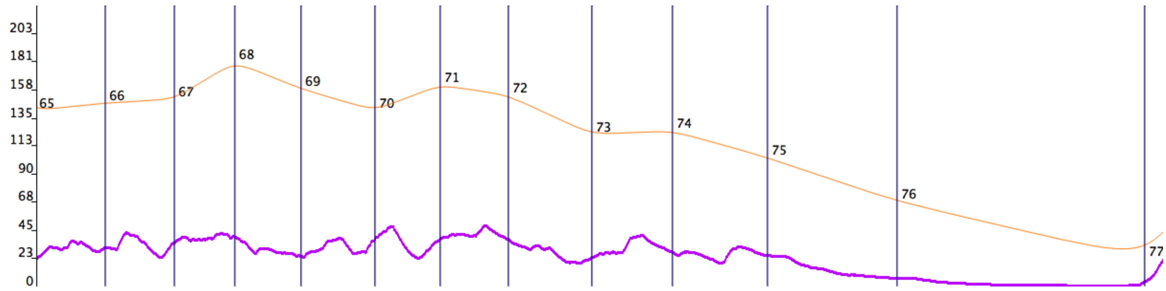

Figure 14b. Improvised performance of Ravel bars 65-77 (reprise).

The prepared and improvised performances of the four-bar codetta (bars 91-94/95) can be seen and heard in **Audio-Visual 19** and **Audio-Visual 20** respectively, and the corresponding tempo and dynamic graphs are shown in Figures 15a and 15b. In the prepared performance the performers emphasised every crotchet beat as they approached the top D flat in bar 93. In the improvised performance, however, they avoided this despite the very slow tempo – the score specifies *très lent* – and used a wider, more continuous crescendo producing an over-arching line and therefore a more coherent build-up from bar 91 to bar 93. Again, the variations of intensity are more evident in the audio-visual recording than the amplitude graphs. Although a *diminuendo* is marked in the last two bars of the movement, observed by the flautist and viola player in the prepared performance, they made an unexpected *crescendo* instead in the improvised performance, as can be seen from the amplitude curves in Figures 15a and 15b.

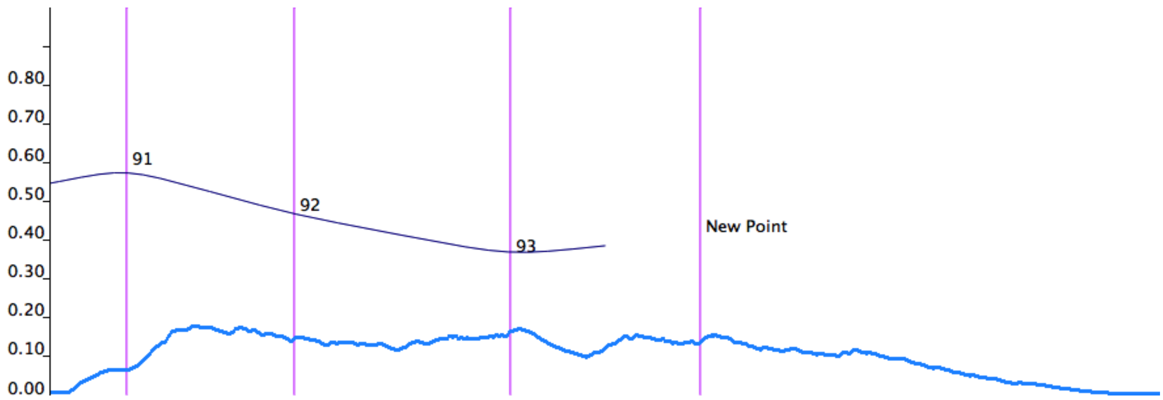

Figure 15a. Prepared performance of Ravel bars 91-94 (codetta).

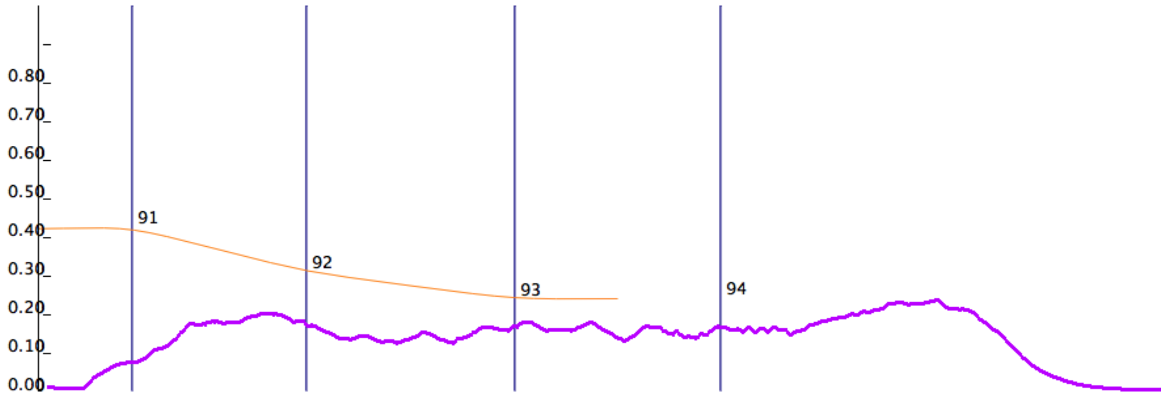

Figure 15b. Improvised performance of Ravel bars 91-94 (codetta).

In summary, despite the different periods and stylistic languages of the works by Telemann and Ravel, we found similarities between the ways the musicians responded to the task of presenting prepared and improvised performances of each work. These similarities included the use of a regular, short-term and somewhat rigid pulse in the prepared performances, while a larger tactus was used in the improvised performances. Phrase structure, too, was more coherent in the two improvised performances. These can plausibly be accounted for as the result of grouping larger chunks, and a greater awareness of the 'inner plan' of the composer deriving from applying the Schenkerian approach as internalized by the performers during their training in improvisatory approaches, as described above. Awareness of structure facilitates longer-range musical shaping: instead of aiming for the next beat, performers can aim for the next 'musical moment', which is likely to reflect a significant structural feature.

Ravel's Minuet differs from Telemann's Adagio in that it is longer and more elaborate. The musicians made connections across the different sections of the movement that might not have been immediately obvious to listeners during the concert but are evident in the data: for example, in the prepared performance copying the opening phrases almost exactly in the reprise, but varying them in the improvised performance.

Emergent themes arising from the analysis that further distinguished the improvised and prepared modes of performance include, as illustrated above, a greater sense of organic development and overall coherence in the improvised performances, exemplified by the clear directionality of phrasing and consistent flow in performance. In addition the musicians appeared to exhibit a kind of 'inner listening', both in terms of their awareness of compositional structure as well as their attunement to the other players and their musical input.

DISCUSSION

This study is the first to have examined the impact of classical improvisation in live concert on both performers and listeners. Although it is a preliminary pilot study, the findings clearly indicate that the presence of an improvisatory state of mind in performance results in greater degrees of engaged listening (subjective feedback) and synchrony of brain activity (objective feedback) between performers and listeners. These effects occur even in cases where there are few or no extemporised notes involved.

The data collected allow us to juxtapose analyses of performances with those of EEG measurements. Interpretation of EEG responses is of course only indicative. No mechanistic relationship exists between the excitation of a brain region and emotional or cognitive state. Nevertheless, to assess a tentatively-proposed relationship between state of mind and brain excitation, we relate the measured differences in EEG activity to the traditional Brodmann areas and their suggested functionality (Brodmann & Garey, 2006). EEG data suggest that while being in an improvisational state of mind, performers' attention to short-term details is decreased, allowing a more intuitive attitude. Analysis of the performances reveals that in an improvisatory state of mind more attention was given to longer-term gestures, phrasing was more coherent structurally while at the same time spontaneously departing from commonly used conventions. This might be seen as an unexpected result, since improvisation, because of its unplanned nature, is often presumed to be unstructured and less coherent than non-improvised performance.

The ensemble members also performed a higher level of risk-taking and more challenging between-performer listening activities while in the improvisatory state of mind: for example, keeping together while one of the players extemporised notes or deviated from previous patterns of phrasing. The audience data indicates that listeners responded more strongly to the improvised versions on the five dimensions tested ('improvisatory in character', 'innovative in approach', 'emotionally engaging', 'musically convincing', and 'risk-taking').

Given the predominance of homogeneity in the performance of particular pieces by individual artists throughout their careers as suggested in the performance literature (Philip, 2004; Repp, 1991, 1992), these data are particularly telling in their demonstrations that making musically compelling changes in interpretation from performance to performance is both possible, and engaging for an audience.

Our data suggest that the performers were in a state of heightened listening or attunement during the improvised mode, as evidenced by their rhythmic flexibility and ability to give musical space to the other players who may have been extemporising notes or leading a *rubato*. This is in accordance with the findings of Sawyer (1992, 1999), Seddon (2005) and Seddon and Biasutti (2009).

In terms of the EEG results, it is difficult to suggest similarities with fMRI studies, since fMRI studies offer more localized observations of brain activity than those provided by EEG. However, it is reasonable to argue that there are similarities between our results and those of past research, and that they may form parallel conclusions. For example, the 'attention deactivation' shown in the improvised mode is similar in definition to the 'expertise-related deactivation' found by Berkowitz and Ansari (2010), where our results show that listeners also exhibit the same increased sense of motivation and free will as the musicians. Whilst Limb and Braun (2008) were concerned with jazz improvisation, our results appear to point in the same direction regarding "widespread deactivation of lateral portions of the prefrontal cortex together with focal activation of medial prefrontal cortex" (Limb & Braun, 2008, p. 3).

The present results therefore support the notion that creative behaviour is largely controlled by the same cortical areas that are involved in other forms of free generation of action. With some support from previous research (de Manzano et al., 2012b; Limb & Braun, 2008), it is tempting to speculate that what separates creative from non-creative cognition is rather a change of mode of function (shifts from excitation to inhibition and vice versa for different cortical areas), than a difference in regional distribution or magnitude of activity. What would determine such cognitive modes remains to be revealed.

As a preliminary study, there are obviously a number of limitations that affect the generalisability of these findings. These results do not permit any understanding of the effect of different concert settings or locations, or of individual differences between performers and listeners.

We believe that this line of research has direct implications for music performance practice. Those who are working to increase the use of improvisation in classical training programmes and classical performance practice may be encouraged by the preliminary data provided here. They suggest that improvisatory approach may encourage enhanced creativity on the part of performers, and a deeper and more fulfilling musical experience for audience members. These considerations may also be a good reason to consider rethinking the role of improvisation in classical training programmes and professional performance practices at large.

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