Performance Micro-Gestures Related to Musical Expressiveness

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ABSTRACT

In the recent framework of embodiment in music research, the mechanisms of the action-perception cycle are regarded as a basis for music cognition and aesthetic musical experience. Our case study aimed at investigating these mechanisms related to a high-level process of experience of musical expressiveness. Three professional musicians – gamba player, clarinetist, and singer – were instructed to play two pieces which they have never played yet, but the style of which they are familiar with. Each of these pieces was played sight-reading, then again after 20 minutes practice. A starting point of our study was the assumption that professional musicians would experience their sight-reading performances as less expressive, compared to their final performances due to the different performance conditions concerning the coordination of auditory and motor processes as well as the interplay between interpretative and performative expressiveness, and each performer's micro-gestures preparing and closing musical passages would correspond to musical expressiveness experienced by her or him. Performance micro-gestures preparing and closing musical passages were identified, based on the annotation of the high-speed video, and the corresponding motion capture data were analyzed. Additionally, timing and dynamic changes in the audio were quantified. The musicians' self-reports on bodily and/or visceral reactions noticed during the ongoing processes of music performance and on experienced musical expressiveness, which were collected through post-experimental oral interviews, were taken into account to interpret the results of analyses of the motion capture data and the audio data. The results imply that musically relevant preparatory and retrospective micro-gestures that might be conceived of as perceptually guided actions embody musical expressiveness emerging during the ongoing processes of music performance, which is monitored or/and pre-reflectively felt by the performer.

1. BACKGROUND

In recent publications in Systematic and Cognitive Musicology, the role of action-perception loops for music cognition (Leman, 2007; Seifert & Kim, 2006) and aesthetic perception of music (Kim, 2005) has become a relevant topic. In detail, some theoretical ideas of how music perception is guided by (inner) action (cf. God∅y, 2001, 2003, 2004; Kim, 2005) and to what extent music making is guided by self-perception (cf. Kim, 2005; Seifert & Kim, 2006) have been discussed. Psychological studies related to music processing have also paid attention to action-perception loops underlying not only in music perception but also in music production (e.g. Pfordresher, 2005; Pfordresher & Palmer, 2006; Repp & Knoblich, 2004). In neuroscientific research on music performance, too, the coordination and coupling of auditory and motor processes in music making and perception have been increasingly investigated (Haueisen & Knösche, 2001; Bangert, Haeusler & Altenmüller, 2001; Haslinger et al., 2005; Bangert et al., 2006; Kleber et al., 2007; Lahav, Saltzman & Schlaug, 2007; Zatorre, Chen & Penhune, 2007). The role of action-perception loops in music perception and production for a high-level process of experience of musical expressiveness, however, has not much become the focus of attention yet.

Our case study addresses musical expressiveness experienced by professional musicians during their own music performance. A main hypothesis of our study is that the mechanisms of the action-perception cycle underlying in music performance serve as a basis for musical expressiveness experienced by professional musicians both pre-reflectively and reflectively during the ongoing processes of music performance. To test this hypothesis, we took a sight-reading performance and a practiced performance of the same music piece, which the test persons have never played yet, as two different conditions of music performance, which may have impact on underlying action-perception loops and on musical expressiveness experienced by the test persons.

Our study attempts to take into account both the musicians' first-person reports on musical expressiveness collected through post-experimental interviews and the third-person data of the same musicians' corporeal gestures indicating experienced musical expressiveness. Though music performance uses a variety of different types of expressive bodily gestures (Dahl & Friberg, 2004, 2007; Vines et al., 2003; Wanderley et al., 2005), our attention is directed towards professional musicians' micro-gestures related to a musical passage in terms of its preparation and closure. The gestures preparing or closing musical passages are guided by anticipatory or retrospective aural senses so that gestural

actions are related to the sounds to be produced in the following or decaying in the ongoing process. Such micro-gestures tend to transcend the momentary event into the direction of previous musical events or following musical events, guided by auditory and kinesthetic feedback. They may serve as indicators for musical expressiveness experienced by professional musicians during the ongoing processes of music performance, with regard to both musical interpretations and momentary expressive feelings.

Against this background, our case study aims at investigating the relationship between measurable performance micro-gestures, which we call preparatory and retrospective gestures, implicitly and explicitly used by a professional musician in different performance situations, and musical expressiveness experienced by the performer.

2. PROCEDURES OF THE CASE STUDY

2.1 Pre-experimental discussions

There has been little research on the relationship between performance micro-gestures and experienced musical expressiveness. Hence, we developed a case study exploring the third-person data obtained from the recordings of music performance in relation to the test persons' first-person reports as a first step. Our case study was carried out with three professional musicians – gamba player, clarinetist, and singer – who are also musicologists. Pursuing a phenomenological approach, the test persons were partially involved in developing a design of the case study and research questions together. For this purpose, a pre-experimental informal questionnaire was used to find out how the test persons experience musical expressiveness during their own music performance pre-reflectively and reflectively. The questions were as follows:

- How do you consciously monitor your performance?
- Do you have quasi-emotional states during music performance? How are you aware of them?
- Do you have bodily or visceral reactions during music performance? What kinds of reactions are they? How do you get aware of them?

Through detailed discussions with the test persons, different performance conditions consisting of sight-reading and practiced performances were taken to investigate musical expressiveness pre-reflectively and reflectively experienced by professional musicians during music performance. The test persons contacted their teachers or colleagues to get recommendations for two music pieces they have never played yet, but the style of which they are familiar with. They have not had a look at the scores of recommended music pieces until the case study day.

2.2 Case study: Instructions

The test persons were separately invited to participate in the case study. They were instructed to play two pieces recommended by their teachers or colleagues. Each of these pieces should be played sight-reading, then again after 20 minutes practice. They should try to follow their ongoing bodily and visceral reactions during each performance and to focus on musical expressiveness experienced during the ongoing processes of music performance. After the case study, they should fill in a questionnaire, based on which a further oral interview is planned in the following days. They were informed of the recordings of both performances by audio and video recording devices (including high-speed video) and motion capture devices based on optical tracking.

2.3 Case Study: Technical Setup

The recordings of the performances by the musicians were done in the laboratory of IPEM where a Motion Capture system (Optitrack, Natural Point) is installed. This Motion Capture system allows the measurement of the positional information from different parts of the body of the musicians and their instrument using IR reflective markers. These data were recorded at a sampling rate of 100Hz and further analyzed offline. For this experiment the audio was recorded using a Shure Beta 87 microphone connected to a Fireface 400 firewire audio interface linked to a Max/MSP patch. This patch enabled a synchronized recording of both audio and motion capture data through the control of an Arduino card which powers IR lights. These lights are detected by the motion capture system as markers and can be switched on the moment the audio recording starts marking a reference point in the motion capture data. Furthermore, the upper body of the performers was filmed using a Casio EX-F1 digital camera enabling a high-speed video recording at 300fps. For this recording extra lighting was installed to compensate for the short exposure time of the camera. Also an overall HD video recording was made using a Canon HV30 camera.

3. RESULTS OF DATA ANALYSIS

In the analysis of recorded data, video annotation starting from high-speed video recordings was first used to find musical passages where preparatory and retrospective gestures were not only clearly visible but also obviously different between the corresponding sight-reading and practiced performance. Motion capture data were then used to compare these gestures between both performances and changes in the audio were analyzed. Finally, the results of these analyses were compared to the test persons' self-reports on experienced musical expressiveness collected through the post-experimental

interviews, taking into account the latter for the interpretation of the former.

3.1 Annotation of the High-Speed Video

Based on the scores, musical passages were analyzed and corresponding corporeal micro-gestures preparing and closing such musical passages were manually annotated from the high-speed video recordings of the sight-reading and practiced performances of each music piece. The gamba player's significant micro-gestures were found in the performances of *Sarabande*, the third suite (e-minor) from the "premier livre de pieces de viole" by Roland Marais (1735): preparatory gesture before the first phrase (gesture 1), retrospective and preparatory gestures between sub-pharases in the first phrase (gesture 2), retrospective and preparatory gestures between the first and the second phrase (gesture 3), retrospective and preparatory gestures before the repeated first phrase (gesture 4), and retrospective gesture after the last phrase (gesture 5). Gestures 1-4 indicate that essential differences consist in the presence and absence of left upper arm movements in every micro-gesture annotated and in those of head movements on occasion. Whereas the gamba player's left upper arm remains static except for fingering movements in the sight-reading performance, it tends to get wider or to move outwards and inwards, forming a preparatory or retrospective gesture in the practiced performance. The gamba player's head occasionally moves downwards, approaching the body of the gamba.

The clarinetist's preparatory or retrospective gestures that were clearly visible were observed in the performances of "After you've gone" by Creamer and Layton, especially in the first phrase: preparatory gesture before the first phrase (gesture 1), retrospective and preparatory gestures between 1st motive and its repetition in the first phrase (gesture 2), retrospective and preparatory gestures between the repetition of 1st motive and its variation in the first phrase (gesture 3), and retrospective gesture after the last phrase (gesture 4). These micro-gestures mostly consist of vertical and horizontal movements, raising or falling the clarinet and turning the clarinet left or right. In general, instrument-turning movements have a wider range of the space in the practiced performance compared to those observed in the sight-reading performance.

The singer's performances showed very obvious differences between overall macro-gestures in both performances: The singer hardly moved in the sight-reading performances, whereas the practiced performances were accompanied by big arm movements as well as by eyebrow and mouth movements. As a result, there were little comparable micro-gestures under the sight-reading and practiced performance conditions. Hence, an analysis of the motion capture data obtained from the singer's corporeal gestures proved to be not appropriate to investigate performance micro-gestures indicating not only reflective but also pre-reflective experience of musical expressiveness. Rather, analyses of the singer's respirations or muscle tensions might provide corresponding results (cf. analyses of the interview with the singer in 3.2). However, we have not taken an additional measurement in our case study.

3.2 Analyses of the Interviews

Based on an informal questionnaire with following questions, which was filled in by each performer after the case study, oral interviews with each performer were carried out.

> 1. How do you judge your sight-reading performances? Were they more than simple sight-reading performances? If either yes or not, how did you notice this?
>
> 2. Did you consciously monitor your sight-reading performances? If yes, what did this monitoring look like?
>
> 3. Were there any bodily or visceral reactions during your sight-reading performances? If yes, do you remember what they felt like?
>
> 4. Did you experience your sight-reading performances as expressive? If either yes or not, what does your experience look like?
>
> 5. Did you find your practiced performances expressive? If either yes or not, what does your experience of musical expressiveness look like?
>
> 6. Did you consciously monitor your practiced performances? If yes, what did this monitoring look like?
>
> 7. Were there any bodily or visceral reactions during your practiced performances? If yes, do you remember what they felt like?

The gamba player answered that he monitored consciously technical aspects, especially left hand positions with regard to fingering techniques, during the sight-reading performances. In the practiced performances, he could notice "his swinging shoulder" along the ongoing processes of music performance, which he characterizes as a natural movement accompanying his music performances. In the sight-reading performances, but some visceral reactions indicating tension and stress were noticed instead of bodily reactions that felt like naturally. For him, musical expressiveness is not only concerned with basic aspects of a musical interpretation, but rather with "micro-level expressiveness" that emerges during the ongoing processes of music performance.

For the clarinetist, an expressive music performance is characterized by "flow experiences" guided by "unconstrained and effortless feelings". He is normally not aware of musical expressiveness during the ongoing processes of music performance, except for a case in which something wrong happens, for instance a case in which "bodily movements interfere with instrumental techniques". Then he concentrates consciously on "proximal bodily actions" and "kinesthetic feedback" rather than "aural feedback". In our case study, he

monitored consciously the sight-reading performances and noticed musical expressiveness due to this monitoring, instead of going along with the performance as in the case of a practiced performance.

For the singer, the sight-reading performances were definitely less expressive compared to the practiced performances. She was aware of "her nervousness and bodily tensions", only focusing on the "intramusical features" of the music pieces. In the practiced performances, she could consciously monitor some changes of her facial expressions and hand gestures corresponding to her "prepared emotional intentions", which were confirmed through "aural feedback". On the other hand, she noticed breathing and muscle activities automatically in the practiced performances. Normally she only gets aware of them, when they somehow interfere. They are then consciously monitored.

3.3 Analyses of the Motion Capture Data

For the analysis of the motion capture data obtained from the gamba player the focus was on the elbow of the left arm. The choice of this location was based on the annotation of the high-speed video. The analysis of the micro-gestures was focused on three moments in the first phrase of the piece and the final retrospective gesture at the end of the piece. To quantify the measurements of the movement the distance of the elbow to the center point of the hip (defined by the mean of the 4 markers placed on the hip) was calculated. This allows a relative calculation with respect to a fixed point on the performer. For each of the four micro-gestures the average value and the average absolute difference between sample points was calculated for this distance. The result of these calculations can be seen in figure 1 and figure 2.

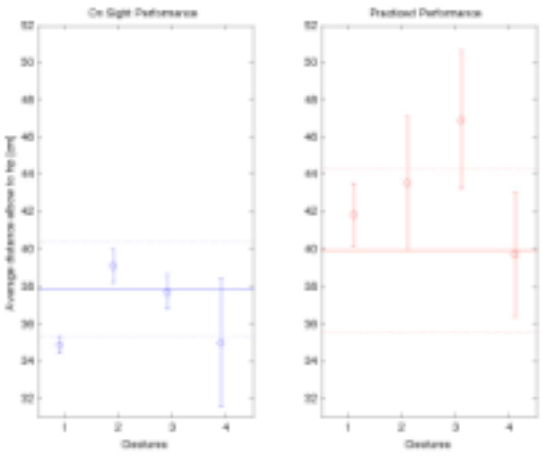

Figure 1: The average distance of the elbow to the center point of the hip for the gamba player for three micro-gestures during the first phrase and the final retrospective gesture at the end of the piece. The horizontal lines indicate the average over the entire piece together with the +-1 std interval, the error bars on the data points correspond with a +-1std interval. For the on sight reading and practiced conditions on the left and right respectively.

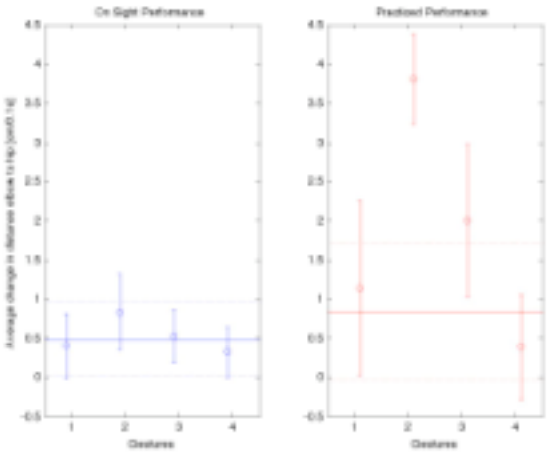

Figure 2: The average of the absolute difference of the distance between the elbow and the center point of the hip for the gamba player. The same gestures as in figure 1 were under study.

From figure 1 it is clear that overall the elbow was further away from the hip in the practiced condition compared to the first performance. Furthermore, the micro-gestures in the first performance differ less from the average over the entire performance, indicated with the horizontal line, compared to those in the practiced performance. This indicates a wider, more open posture in the second performance. Also the error bars in the first performance are small for the first 3 micro-gestures compared to that of the last gesture. This reflects a smaller range used by the movement in the first 3 micro-gestures. Comparing the two performances the error bars are larger in the practiced performance showing a larger range in distance used by the performer except for the final gesture. When looking at the results on the average absolute change in position of the elbow during the micro-gestures in figure 2 it is clear that overall there is more movement in the second performance. Again, there is a larger distinction between the micro-gestures and the overall average in the practiced performance. There is a similar trend in the two performances for the movement during the micro-gestures where the trend is much more pronounced in the second performance.

For the clarinetist we focused on the absolute height of the bell of the clarinet. This has proven to be a key element in musical expressivity of clarinetists (Wanderley et al., 2005). For the first three micro-gestures in the first phrase and for the final retrospective gesture at the end of the piece the vertical position of the bell is studied by calculating the average height and the average of the absolute difference in height. The results can be seen in figure 3 and 4.

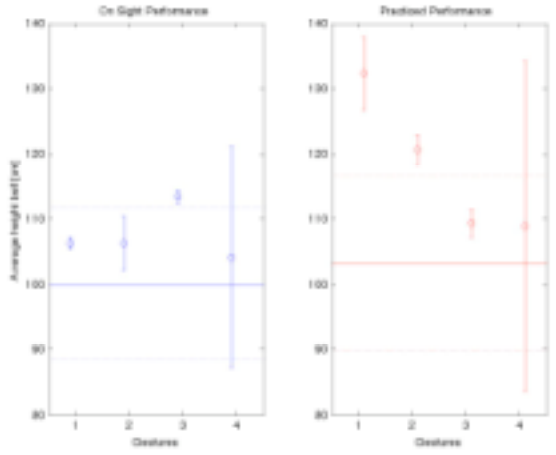

Figure 3: The average height of the bell of the clarinet for three micro-gestures during the first phrase and the final retrospective gesture at the end of the piece. The horizontal lines indicate the average over the entire piece together with the +-1 std interval, the error bars on the data points correspond with a +-1std interval. For the on sight reading and practiced conditions on the left and right respectively.

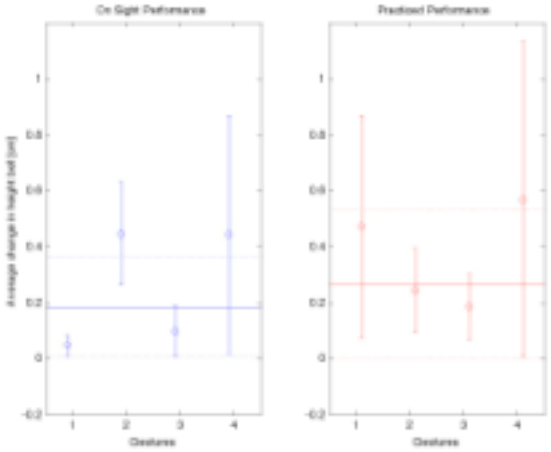

Figure 4: The average of the absolute difference of the height of the bell of the clarinet. The same gestures as in figure 3 were under study.

The error bars in figure 3 for the on sight performance indicate that in the first three micro-gestures there was only a small range of vertical displacement used which increased for the final gesture. In comparison with the practiced performance this final gesture was even more elaborate after practice. Also the average height of the bell differs more from the global average in the practiced performance. Turning to the results presented in figure 4 we can see that the global average and standard deviation of the absolute change in height of the bell is somewhat larger in the practiced performance compared to the on sight performance. This indicates a higher velocity and a greater variation of this velocity in the movement of the clarinet.

Overall we can say that a larger range of the space is used during micro-gestures after a practice session compared to an on-sight performance.

3.4 Analyses of the Audio Data

The audio analysis is related to the motion capture data analysis, focusing on the timing. Therefore the note onsets were manually annotated with the aid of the program Praat (Boersma & Weenink, 2008). First we can make some general analyses of the timing, then take a closer look at the locations of the preparatory and closing gestures presented above, for which we can include some details about timbre and dynamics.

One would expect the average tempo to be significantly slower in a sight-reading performance. However in the performance of the gamba player, we see exactly the opposite, with the average tempo decreasing from 62.1 bpm in the sight-reading performance to 53.5 bpm in the practiced performance. If we take a closer look at the timing, we see that the decrease in tempo in not linear. Rather we see that more time is taken at phrase boundaries and that timing contrasts are exaggerated. Thus we see that the average length of small ornamental notes slightly diminishes from 199 to 195 ms, the 16^{th} notes stay almost the same (325/327 ms), but we see a huge increase for the dotted quarter notes (1060/1408 ms) and especially the dotted 8^{th} notes (681/1022 ms), this shows that the temporal contrast in dotted figures is increased. The increased duration contrast is also shown by the normalized pairwise variability index (nPVI; Low, Grabe & Nolan, 2000), which increases from 70.0 in the sight-reading performance to 83.1 in the practiced performance. As the main differences are the increased durational contrast and a somewhat slower global tempo, the correlations between the timing of the two performances is still very high: r = .93 on the actual durations and r = .73 if we calculate the unit length (actual duration divided by the notated length, expressed as the number of 16^{th} notes)

In the two clarinet performances, we see that the global tempo hardly changes, from 89.7 bpm in the sight-reading performance to 91.4 bpm in the practiced performance. In fact the timing is at many places virtually identical, with differences below 10 ms, which would be close to the measurement error. Two reasons can be seen for the small increase in tempo: (a) the occurrence of some unexpectedly large durations in loops of 16^{th} notes, that can be interpreted as hesitations due to sight-reading at a relatively high note rate, and (b) also a tendency to increase durational contrast, with short rhythmic values being shortened and the longer values being elongated in the practiced performance. However, this increase in durational contrast is not reflected in the nPVI, which is quasi identical for both versions (33.8/33.4). More interesting are the data on the swing ratio, the ratio between pairs of 8^{th} notes, which are performed 'unequal', with the note on the beat being prolonged compared to the off-beat. The swing ratio increases from 1.67 to 1.71 in the practiced performance, but at the same time the variability decreases, with standard deviation dropping from .56 to .43. So, although

the average swing ratio becomes slightly more unequal, it gets more stable, which decreases the overall durational variability.

We can now look at the passages that correspond to the specific preparatory and retrospective gestures that appear in the practiced performance, as identified through the high-speed camera analysis. For the performance of the gamba player, the appearance of the expressive gestures is clearly reflected in the timing and dynamics of the performance. The preparatory and retrospective gestures all occur at structurally important points, which generally receive more time in the practiced performance. Excluding the preparatory gesture for the first note, which does not occur during a note, the durations of the other four notes increases with 41%. Both preparatory and retrospective gestures are also reflected in the timing of the dynamics. At the first note we see that the rising time considerably increases from 46.6% of the total duration to 63.1% in the practiced performance. At the repeat of the first part, the rising times lay around 45% in both cases, but the change in dynamics is much bigger in the practiced performance 32-52db, as compared to the sight-reading 34-45db. Concerning the preparatory gestures, the retrospective gesture of the third bar (gesture 2) shows a change in phrasing, with a short note in the first version and a longer note in the final performance. This is reflected in the decay time which decreases from 58.9% to 10.6% of the total duration. The retrospective gesture of the 5th bar (gesture 3) shows the largest increase in duration (55.7%), even then, the relative share of the last part (after the trill) increases in the practiced performance from 33.3 to 39.9%. At the final cadence we see also see a very large increase in duration at the last beat (+51.1%). Also here the dynamics show a very different profile, with a sudden stop in the first version (decay time 193 ms) and a slow, gradual end in the final version (2721 ms).

Also in the clarinet performance we see that the places where expressive gestures appear in the practiced performance go along with changes in phrasing, which are reflected in the timing and, in this case, especially in the dynamics. After the first motive, in the sight-reading performance, we find only a limited decay (76.7 to 61.6 dB) and the average loudness of the first note of the next phrase stays at a similar level (70.4 dB). In the practiced performance, the clarinetist changes his interpretation making a strong dynamic change with a decay from 75.5 to 49.4 dB and playing the first note of the next motive piano with an average loudness of 52.3 dB. Despite this dynamic contrast, the timing was hardly affected. At the end of the second motive, the sight-reading performance shows a small dynamic change from an average loudness of 71.3 dB on its final note to 68.7 dB for the first note of the third motive. In the practiced performance we see an opposite movement from 65.0 to 71.4 dB. In this case the phrasing contrast is clearly also reflected in the timing: from 732/203 ms (a 3.6 ratio, close to the notated 4:1), the timing changes to 510/348 (close to a 3:2 ratio), thus clearly emphasizing the onset of the next motive. Finally, also at the end, the retrospective gesture accompanies a more sophisticated interpretation: the stable part of the final note gets shorter (from 1253 to 1110 ms) and somewhat softer (from 74.1 to 72.3 dB just before the decay), but the decay time gets somewhat longer (from 505 to 525 ms), these differences might seem subtle, but still they are very apparent in the sound.

3.5 Interpretation of the Third-Person Data in Relation to the First-Person Reports

The analyses of the motion capture data and the audio data obtained from the sight-reading and practiced performances are based on third-person perspectives. In our case study, we attempted to relate these third-person data to the results from the interviews collecting the musicians' first-person self-reports on experienced musical expressiveness guided by bodily and/or visceral reactions. For the gamba player, the obviously different movements of his left upper arm observed and measured in several significant micro-gestures between the sight-reading and practiced performance can be interpreted in relation to the gamba player's reports on tension and stress during the sight-reading performances and on 'naturally' swinging shoulder movements noticed by him during the practiced performances. The small range of the gamba player's left arm movements in the micro-gestures of the sight-reading performance points to his concentration on left finger positions reported by him, which does not lead him to go along with music in a 'natural' way. On the contrary, the wider range of his left arm movements with an increase in duration of the corresponding notes during the practiced performance is related to the gamba player's report on feelings of going along with music expressively, noticing his swinging shoulder.

For the clarinetist, the larger change in height of the bell in connection with the contrast in dynamics analyzed from the practiced performance is related to his report on musical expressiveness pre-reflectively felt during the practiced performance compared to musical expressiveness reflectively monitored during the sight-reading performance. Especially the changes in dynamics shown over the changes in timing by the analysis of his performances is supported by "his concentration on timing and rhythm during both performances" reported by him, which indicates that the changes in dynamics he apparently did not pay attention to seem to be related to micro-level expressiveness pre-reflectively felt by him during the ongoing processes of the practiced music performance.

4. CONCLUSION

Our case study was a first attempt to investigate musically relevant bodily micro-gestures preparing and closing musical passages related to musical expressiveness experienced by professional musicians during their own music performance. The question of how such micro-gestures embody musical expressiveness emerging during the ongoing processes of music performance was investigated under different performance conditions, modifying the constraints of music

performance and indirectly affecting the mechanisms of the action-perception cycle underlying in professional music performance. The results of our study combining the analyses of the motion capture data and the audio data with the musicians' self-reports on experienced musical expressiveness show that the music performances monitored or/and felt as more expressive by the professional musicians comprise preparatory and retrospective micro-gestures which intra-personal properties related to each performer are ascribed to, such as horizontally wide movements of the gamba player's left upper arm and the clarinetist's movements raising the clarinet using a large range of the space. To investigate more general intra-personal properties of such gestures, a further study with a wide variety of music pieces would be necessary.

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