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Analysis of Drum player's motion

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Abstract
In this experiment, the motion of a drum player's arm was measured by the optical motion capture system in various performance types. From these actual movement data, we analyzed about the acceleration and sound energy flux of the stick before and after excitation. Moreover, the snap of a wrist which is very important at the time of a high drum performance and the relation of acceleration, and the relation of sound energy flux were also analyzed. From those results, it was suggested that the snap of the wrist was important at the time of a high drum performance, and it was concerned with sound power. Especially, the performance which player hit the drum speedy and repeatedly was concerned with the acceleration of stick before and after excitation.

1 Introduction

The purpose of this research is to solve the effective performing method in a drum performance. It is efficient to clarify suitable movement at the time of a performance in improvement in the degree of skill of a performance, and to master it. Then, we conducted movement analysis of a snare drum performance using the motion capture system.

Tsuji et al. [1] considered the difference between the person experienced in a percussion instrument, and an inexperienced person using the MIDI drum and the simple motion capture system for the purpose of the study support by the form improvement of a percussion instrument performance. As a result, the significant difference was found out to the motion of the back of a hand among subjects.

Moreover, Furukawa [2] has advocated using the muscular group in a performance as a skill rule to the bowing of a cello. It is appropriate to use whip movement and pendulum movement.

Furuya et al. [3] propose that sound volume control is achieved by an "impulse strategy", whereas striking tempo control is made by a "moment of inertia strategy". To control sound volume and striking tempo simultaneously, pianists selected an intermediate way of these two strategies where movements at the elbow joint played a major role in keystroke.

In the articles that have referred about individual difference of musical motion, the study of Turner-Stokes [4] suggested that clear and reproducible differences in style and technique were demonstrated between individuals. The increased range of shoulder movement in the upper register of the cello might contribute to the greater prevalence of neck and shoulder symptoms among cellists.

In this research, the stick velocity of the snare drum performance and the relation of upper-limbs movement was considered using a motion capture system. Moreover, examination of the different dynamics and tempo was also performed.

2 Experiment

2.1 Motion Capturing

Measurement was performed by the digital optical motion capture system, MAC 3D System of Motion Analysis. Frame speed was 1/60s and shutter speed was 1/1000s. The markers were attached on the upper half of the body.

Moreover, since the relation between a motion of a stick and the head of a snare drum was also needed, 2 markers were attached on the tips of both sides' sticks, and 3 markers were done on the head of the snare drum. The total of the marker was 30 pieces (Fig.1).

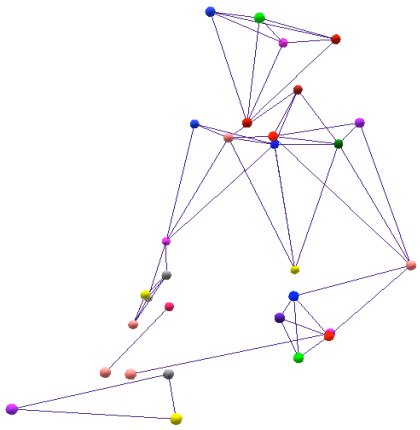

Fig.1 Position of markers

2.2 Musical piece

The musical piece (Fig.2) for this experiment was the etude of a snare drum, and player performed by two patterns of dynamics, pianissimo (pp) and fortissimo (ff). Players were two students - player K had played the percussion instrument for two years, and player M had done for 11 years.

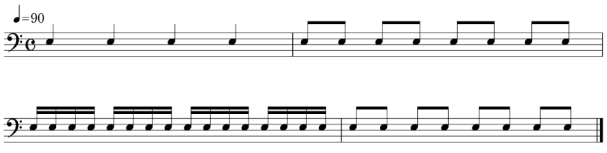

Fig.2 The musical score of snare drum

2.3 Motion Analysis

The analysis section was form the highest point (Z-axis) of stick which was thrown up at the time of 1st drumming to the next highest point where stick bounced back after hitting the head of a snare drum. The velocity and acceleration of the tip of a stick per frame before (pre) and

after (post) hitting the head of a snare drum were calculated on Z-axis. Next, in order to analyze movement of the upper limbs, the velocity and acceleration of each marker per frame for pre and post drumming the head of a snare drum were calculated from the three-dimensional axes on six markers, a shoulder, an elbow, a wrist outside, a wrist inside, an index finger, and the third finger.

3 Results

The relation between the stick average velocity and average voltage of one frame is shown on Fig.3. The average velocity and average acceleration (pre and post) on six points of upper limbs were done on Fig.4 and 5. On Fig.6 and 7, the average velocity of the arms for each note value before drumming was shown too. Moreover, the correlation coefficient of the six upper limbs velocity according to dynamics was shown on Table 1-4.

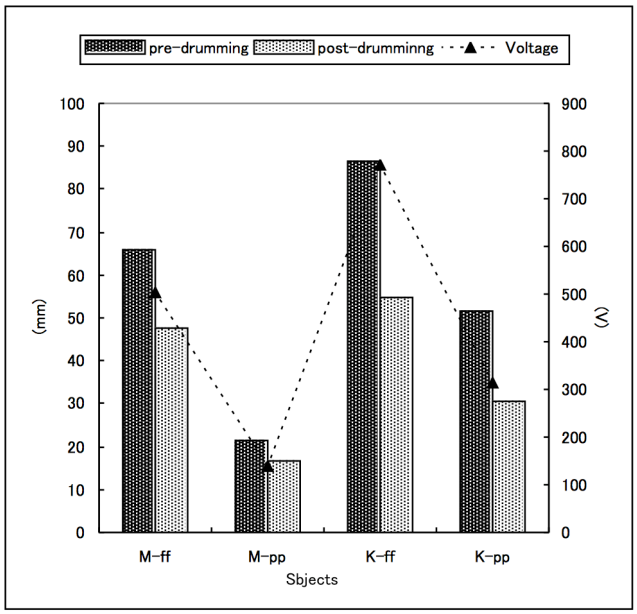

Fig.3 Relations between the average velocity of the stick and the voltage.

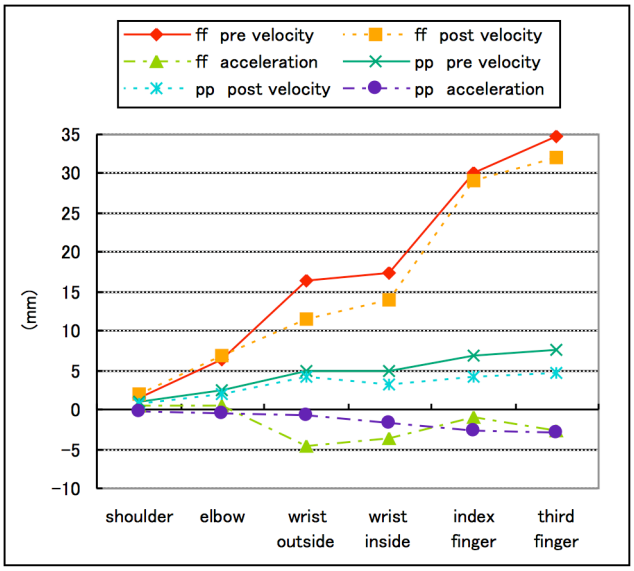

Fig.4 Velocity and acceleration of arms (player K).

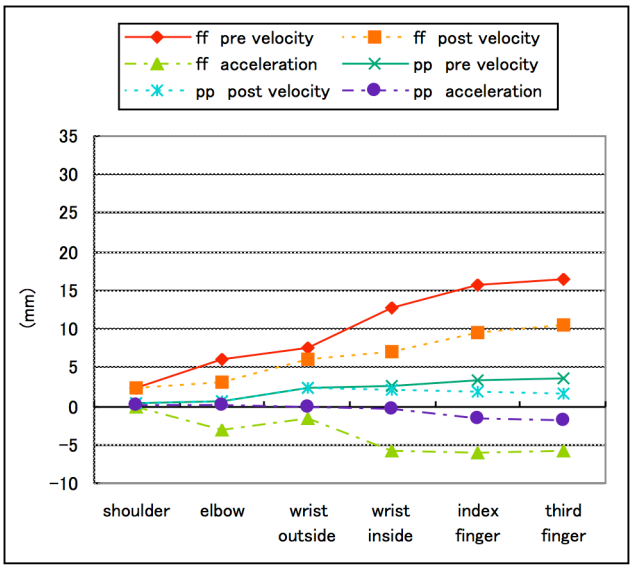

Fig.5 Velocity and acceleration of arms (player M).

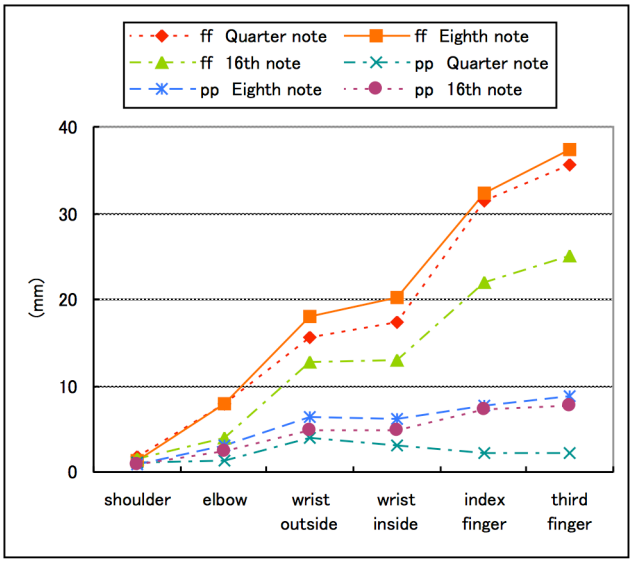

Fig.6 Velocity of the arms for each note value (player K).

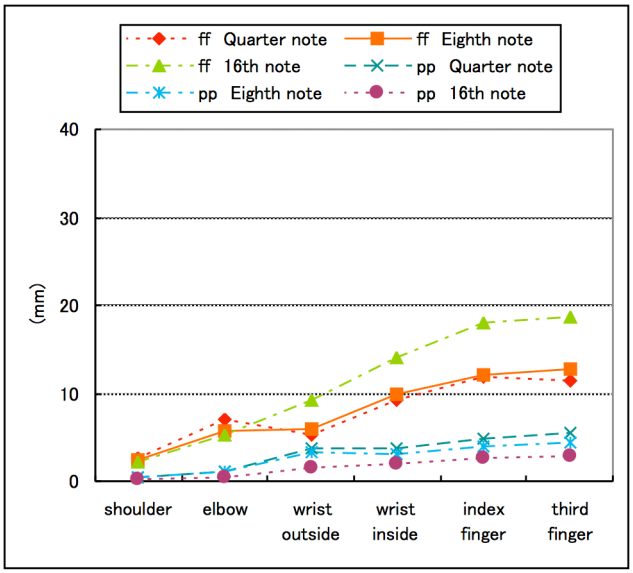

Fig.7 Velocity of arms for each note value (player M).

Table 1 Correlation coefficient of the velocity of the arms for fortissimo (player K).

	elbow	wrist outside	wrist inside	index finger	third finger
shoulder	0.670	0.443	0.480	0.486	0.454
elbow		0.553	0.611	0.619	0.582
wrist outside			0.972	0.919	0.917
wrist inside				0.933	0.922
index finger					0.987

Table 2 Correlation coefficient of the velocity of the arms for pianissimo (player K).

	elbow	wrist outside	wrist inside	index finger	third finger
shoulder	0.752	0.643	0.681	0.628	0.610
elbow		0.712	0.781	0.747	0.702
wrist outside			0.928	0.891	0.886
wrist inside				0.939	0.928
index finger					0.984

Table 3 Correlation coefficient of the velocity of the arms for fortissimo (player M).

	elbow	wrist outside	wrist inside	index finger	third finger
shoulder	0.607	0.466	0.571	0.587	0.552
elbow		0.649	0.753	0.725	0.684
wrist outside			0.934	0.928	0.951
wrist inside				0.984	0.974
index finger					0.990

Table 4 Correlation coefficient of the velocity of the arms for pianissimo (player M).

	elbow	wrist outside	wrist inside	index finger	third finger
shoulder	0.149	0.022	0.171	0.168	0.123
elbow		0.147	0.452	0.422	0.335
wrist outside			0.622	0.625	0.668
wrist inside				0.871	0.838
index finger					0.946

Fig.3 showed that velocity of one frame was relative to the voltage for both players before and after drumming. Fig.4 showed that it was necessary to strike a drum using not only movement of an arm but the snap of wrist like in order to take out big volume, a sort of fortissimo. Moreover, in the case of small volume, a sort of pianissimo, it is necessary to strike using only the snap of a wrist like Player M, without moving the shoulder and the elbow. When striking by pianissimo, it is for suppressing whip movement as much as possible. That can be found out also from the result of a correlation coefficient. As a result of considering the difference in tempo from Fig.6 and 7, it turned out that player K used the snap of the wrist regardless of tempo. But player M did not use the snap of a wrist as tempo becomes quick. This means controlling useless movement using a moment of inertia. However, this controlling is not applicable to fortissimo. Although difference appeared in both players' movement pattern, it turned out that there are merit and demerit in each way of striking about dynamics.

4 Conclusion

Although how to use a wrist and an arm varied with the player, there was no difference in dynamics. The change of dynamics is dependent on how to strike rather than the difference of years of experience.

Acknowledgments

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