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Characteristics of actions for sliding walk technique in Japanese traditional performing art
－Pursuit for Rhythm of Jyo-Ha-Kyu, “introduction, development, and climax” of Hakobi (sliding walk) from proficiency difference in Kyogen actors－

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Abstract

Purpose: This study analyzed *Hakobi*, the sliding walk, as one of the representative performance techniques in Japanese traditional performing arts and we tried to explain the rhythm called “*Jyo-Ha-Kyu*” with the quantitative data.

Methods: We recorded *Hakobi* of 4 *Kyogen* performers in the video image. Performers included the person designated as a Living national treasure. Experimental conditions were controlled by time condition (T) and spatial condition (S) variously. *Hakobi* was examined from the viewpoint of the time requirement (A1), the number of steps (A2), time ratio of each step among the total time (A3), and the timing to step the foot forward (A4). The step that changed the speed was extracted (E1), and their skills for speed adjustment (E2) were discussed.

Results: We found three remarkable skills of *Kyogen* performers. First; the 2nd Step or the 3rd Step was used for acceleration, and the Last Step was used for deceleration (E1). Second; not only the number of steps but also the length of step was used for adjustment of spatial condition (S). Finally; if the conditions are right, time delay on the 2nd Step or the 3rd Step was recognized (E2). By utilizing these skills, non-monotonous rhythm and tempo was produced. We identified that this rhythm and tempo were used for making "*Jyo-Ha-Kyu*" of *Hakobi*. Especially, it was suggested that a process from “*Jyo*” to “*Ha*” has regularity following natural logarithm.

Conclusions: This study succeeded in clarifying that the difficulty of *Hakobi* of “*Jyo-Ha-Kyu*” depended on the embodiment of its natural logarithmic rhythm.

1. Introduction

Traditional performing arts which have been played for a long time in various parts of the world, have been well known as important resources to understand racial aesthetic senses, palate, and entertainment aspect. One of the Japanese traditional performing arts is *Nohgaku* (*Noh* and *Kyogen*). *Nohgaku* is one of the oldest performing arts, established in “*Muromachi*” era,

which has been performed for more than 650 years. It has affected other performing arts, including *Bunraku* or *Kabuki* which were established later, and has an elements becoming the source of Japanese performing art. *Nohgaku* was designated first in Japan as a UNESCO World Intangible Cultural Properties. These acting motions consist of three elements, which are basic posture (*Kamae*), walking performed by sliding walk (*Hakobi*), and movement as an action unit (*Shosa*). Among these, sliding walk has been widely known as the typical performance that was representative of *Nohgaku*, and has been adopted in *Bunraku* or *Kabuki*. In the category of dances such as *Nihon Buyo* or *Ryukyu Buyo*, *Hakobi* was also used for walking. It is said that *Hakobi* in *Nohgaku* has influenced their walk [1],[2] .Therefore, motion analysis of *Hakobi* in *Nohgaku* leads to the understanding of one of the representative performance techniques that spread to the whole performing arts in Japan. It's important, in *Hakobi* of *Nohgaku*, to follows the rhythm called "*Jyo-Ha-Kyu*" [3]. Zeami, who established Noh in *Muromachi* era, said, "The most fascinating part is "*Jyo-Ha-Kyu*" even though it is only in one phrase of performance." [4] It was accepted as an important technique for a long time; many performers explain this as follows with the theory of "*Jyo-Ha-Kyu*". "The speed is accelerated gradually, the strain increased and then a performer stops his/her stepping immediately after absorbing an inertial force at the reaching point" [5], "Mildly and smoothly first, accelerating the speed with changes in the middle and dynamically at last" [6], "Start slowly, increase the pace gradually, and end quietly" [7], "Start up by keeping energy at the stage of "*Jyo*", accelerate the speed by unharnessing it at the stage of "*Ha*" and increase the speed released all at once at the stage of "*Kyu*"" [8]. Judging from these performers' talk, "*Jyo-Ha-Kyu*" consists of 3 sections and the movement has two patterns of acceleration before stopping the step. However, there are no researches that clearly mention the specific point from which "*Ha*" or "*Kyu*" starts. A sequence of "*Jyo-Ha-Kyu*" is only explained as "the rhythm and the flow of act, which starts from "*Jyo*", develop into "*Ha*" and then converge in "*Kyu*"" [9].

It is said that the performers of *Nohgaku* attain greater proficiency after more than 50 years' career from the childhood. Zeami also mentioned what kind of action should be learned at respective performer's ages [4]. But he doesn't explain why the training from childhood is required. So, in the interview by the first author to a *Kyogen* performer, a living national treasure ※1, answered this question, "we cannot acquire the skills of *Hakobi* as "*Jyo-Ha-Kyu*" unless we start the training from our childhood." The skill to add the rhythm of "*Jyo-Ha-Kyu*" to *Hakobi* requires high degree of difficulty and it is hardly possible to obtain it unless the performers start the training from a very young age.

On the other hand, there are some researches about the physical aspects in performing arts. Such as the researches for performing arts using motion capture [10], [11],[12], the patterns of breath of the performers [13], [14],[15], the sliding walk as *Hakobi* including the comparison of muscular activities of walking and floor reaction force about *Nihon Buyo*, *Noh*, and ballet [16a],[16b], about *Kyogen* [17] and 3D analysis of *Ryukyu* dancing [18]. And analyzing the time required the authors show, in the interpretation that one step before the abrupt stopping step corresponds "*Kyu*" of "*Jyo-Ha-Kyu*" [19].

However, these researches were not conducted on the *Noh* stage (*Nohgaudo*) where *Hakobi* is normally performed but under the experimental environments. And there were almost no research that discussed the proficiency difference with the training start age of performers.

So, in this research, we analyze the data of *Hakobi* with "*Jyo-Ha-Kyu*" on the *Noh* stage regarding 4 *Kyogen* performers including a person designated as a Living national treasure. We tried to explain the rhythm called "*Jyo-Ha-Kyu*" with quantitative data, focusing on proficiency which included the difference of performer's training start age. We compared the results to the previous researches that clarified the skill of the exercise and the required process for music rhythm and tempo. Then we discussed the relation between starting age for their training and the performer's acquirement of the rhythm of "*Jyo-Ha-Kyu*".

2. Methods

In this research, we will adopt *Hakobi* of *Kyogen* in *Nohgaku* (*Noh* and *Kyogen*). In *Nohgaku*, it is known that there are some differences in basic posture and *Hakobi* according to schools or associations. And also it is known that there was flexibility by performers. In this research, we compare *Hakobi* of 4 performers of *Ohkura* school, the family, where the stylization are especially strict [20].

Contents of analysis

We analyze *Hokobi* not only in the normal performance condition but also in the experimental conditions. As *Hakobi* had both musical and kinematic factors, we set time condition（T）and spatial condition（S）in the experiment. The demonstrations were analyzed by watching videos of 4 *Kyogen* performers. We set the contents of analysis as the following 4 points. They are the time requirement (A1), the number of steps (A2), time ratio of each step among the total time (A3), and the timing to step the foot forward (A4). By examining the acquired results from the viewpoint of proficiency difference (mentioned below), we searched the step that changed the speed (E1) and skills of the performers for speed adjustment (E2).

However, *Hakobi* is different from the regular walking and is a unique stepping or way of walking where the soles are slipped along the stage surface without raising heels. Its SWING is a style of sliding forward on the floor and its STANCE is a style of lifting the toe and putting down the toe. We define the action which is kept sliding, lifting the toe up and then putting the toe down as 1 step on the same side (STRIDE).

Research participant (*Kyogen* performer):

4 *Kyogen* performers, mentioned below (Table 1), participated in this study. Subject A is an expert that has been designated as Living national treasure. The other three performers have almost the same stage careers. However there is a difference among these three performers: subject B and subject C started the training in their childhood, but subject D started after growing up. In this research, a standard level is set on subject B and C. The proficiency difference is evaluated by two conditions; subject A versus subject B and C; subject D versus subject B and C.

Table 1 Information regarding *Kyogen* performers in this research

Cooperators in the experiment	Debut Age	Stage career	Age(at the time of measurement)	Height	Weight
Subject A※1	5 years old	68 years	73 years old	165cm	65kg
Subject B	5 years old	28 years	32 years old	170cm	85kg
Subject C	6 years old	24 years	30 years old	170cm	67kg
Subject D	25 years old	25 years	50 years old	170cm	71kg

Generally, one's height affects his/her stride, however the stride with *Hakobi* is about 54～70cm [21] and they must perform decided position movement in *Noh* stage with the same number of steps [3].

Date and place, and how to record movements:

February 26, 2010 and March 10, 2010. At Suginami *Nohgakudo* (home *Noh* stage for the research participants). And subjects wore less puffy clothes in order to show the movements clearly. We video-taped the performances from the front, right and left of the stage (Camera A, B, and C in Figure 2) in 30 frames per second. Besides, it is usual to perform in the rehearsal of *Nohgaku* with the same costumes as in the experiment.

The contents of the performance: *Hakobi* contained in the *Ko-Mai*※2 *"Yukiyama"*

We set the speed of *Utai* as background music for *Ko-Mai* as time condition (T) shown in the following three conditions.

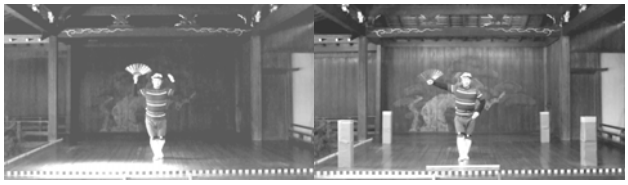
①T-Slow; 1/2×speed, ②T-Normal; 1×speed (normal condition), ③T-Fast; 2×speed

We set the following two conditions as spatial condition (S).

①S-1/1; normal area of the stage (normal condition): The distance for *Hakobi* is about 3meters, ②S-3/4; 3/4 of the normal area of the stage : The distance for *Hakobi* is about 2.3 meters.

"*Yukiyama*" is the performance with 1×speed for 98

seconds. For this research, *Hakobi*, where the performers step forward (Figure 2, 3) from the central rear part (*Daishoumae*) to the central front part (*Shousaki*), with fanning by both hands and then stop stepping was selected. The reason we have adopted this part of *Hakobi* is, that it is performed as the most basic position movement. We do not discuss the movements of the upper limbs in this research, and assume it a future work. And we researched only legs movements by a video which taped with camera A.



S-1/1　　S-3/4

Fig. 1 The scenes of the experiment

One of the important skills among physical training by *Nohgaku* performers is to understand the area of the stage (the area of *Noh* stage 6m × 6m) and always stand completely correctly at the fixed standing position (there are the names respectively at 9 positions of *Noh* stage as shown in Figure 2). It is expected that this skill will have an influence when the movements occur by spatial condition (S).

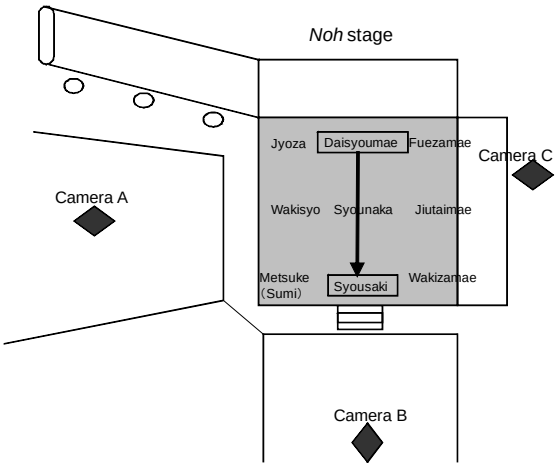


Fig. 2 *Noh* stage and the positions of the cameras

Fig. 3 Consecutive photographs of subject A's steps (T-Fast of S-1/1)

3. Expected Results

Regarding *Hakobi* included in the *Ko-Mai* "*Yukiyama*", we analyzed the time requirement (A1), the number of steps (A2), the time ratio of each step among the total time (A3), and the timing to step the foot forward (A4) under 6 conditions, 3 time conditions (T-Slow, Normal, Fast) × 2 spatial conditions (S-1/1, 3/4).

Regarding the time requirement (A1), we expected that it might be in proportion to the speed as time condition (T) becomes 1/2 or 2 times of the normal speed (P1). Regarding the number of steps (A2), we expected that it might be in proportion to spatial condition (S) (P2), and expected that it might be unified if it was the same spatial condition (S) even it had differences in time condition (T) (P3). Regarding the time ratio of each step among the total time (A3), we expected that the progress for accelerating would be performed based on 2 patterns according to *Geidan* (talk on the arts) that explained "*Jyo-Ha-Kyu*" and be stopped by being slowed down at the last step according to previous research (P4). Regarding the timing to step the foot forward (A4), we expected the possibility that some characteristics of the movements appear due to proficiency difference (P5).

4. Results

4.1. Analysis of the time requirement (A1)

The time requirement under each condition was shown for 4 performers separately in Table 2.

From these, we found that the time used for *Hakobi* was not always the same among 4 performers despite the same background music.

We found out whether the time to perform *Hakobi* would be 1/2, or 2 times of T-Normal in proportion to time condition to be (T-Slow; ×1/2 speed) or (T-Fast;

×2speed). As a result, the values for all the 4 performers were shortened under T-Slow condition within the range of 0.46 to 4.85 sec compared to 1/2 of the values in calculation, and under T-Fast the values became longer compared to 2 times of the values in calculation within the range of 0.36 to 0.78 sec. It means that the values were not in proportion to the speed of the music against our expectation, and all the values tend to come closer to the values of *Hakobi* under T-Normal condition. (P1)

Table 2　The time requirement for *Hakobi*

Time condition(T)	Slow Speed(1/2×Speed)		Nomal Speed(1×Speed)		Fast Speed(2×Speed)	
Spatial condition(S)	1/1(3.0m)	3/4(2.3m)	1/1(3.0m)	3/4(2.3m)	1/1(3.0m)	3/4(2.3m)
Subject A	9.37	9.60	6.01	5.74	3.56	3.53
Subject B	11.81	12.21	7.33	8.51	4.03	4.98
Subject C	13.20	12.61	7.23	6.53	4.13	3.70
Subject D	8.42	10.13	6.63	5.84	3.83	3.70

Unit: sec

Considering the proficiency difference, subject B and C are thought to be a standard because both cases are almost the same under the T-Normal of S-1/1 condition. Subject A had a tendency of required time getting shorter than subject B and C. Subject D had also getting shorter totally but it showed the shortest difference under the condition of T-Slow of S-1/1.

4.2. Analysis of the number of steps (A2)

The relationship among time condition (T), spatial condition (S) and the number of steps is shown in Table 3. In this analysis, we considered the relationship between the changes of spatial condition (S) and the number of steps. Besides the adjustment in the number of steps, we focused on whether the performers make adjustments by step length.

When the area became smaller on the whole, the number of steps became from 2 to 4 steps fewer. (P2) However, under T-Normal and T-Fast conditions for subject A and under T-Slow condition for subject D, no change of the number of steps was found regardless of the size of the area. In these cases, we believed that the performers made adjustments for the size by the length of one step. We found that the number of steps was not unified among 4 performers against our expectation. We also found that there are some cases where the performers make adjustments for the change of spatial condition (S), not by the number of steps, but by the length of the steps. (P3)

Table 3　The number of steps of 4 performers respectively

Time condition(T)	Slow Speed(1/2×Speed)		Nomal Speed(1×Speed)		Fast Speed(2×Speed)	
Spatial condition(S)	1/1(3.0m)	3/4(2.3m)	1/1(3.0m)	3/4(2.3m)	1/1(3.0m)	3/4(2.3m)
Subject A	10	8	10	10	8	8
Subject B	10	8	8	6	8	6
Subject C	10	8	10	8	10	6
Subject D	8	8	8	6	8	6

Unit: step

Additionally, as there is a fundamental rule that performers start the step from the left leg and stop by right leg for *Hakobi* in *Nohgaku*, the number of steps necessarily gives an even number.

4.3. Analysis of the time ratio of each step among the total time (A3)

4.3.1. The characteristics of the changes of the time required for each step

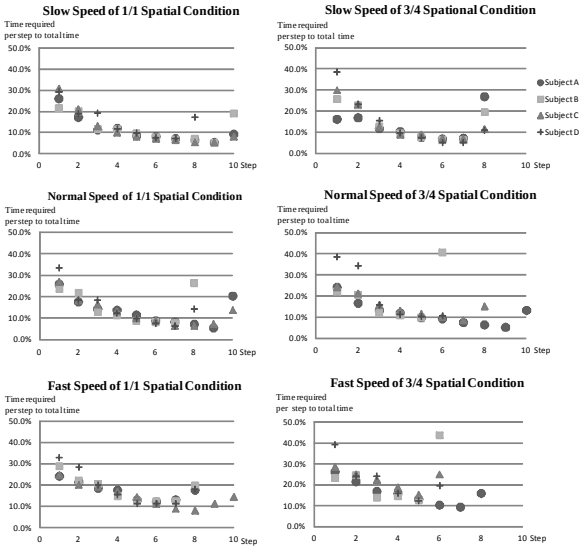


Fig. 4 The time required per step seen in each *Hakobi*

The time required is shown for each performance by percentage notation when one *Hakobi* is set as 100% in

Figure 4. It was expected that the time required would become shorter from the 1st Step based on 2 patterns, become longer at the Last Step and then stopping comes. As a result, it was confirmed that every *Hakobi* had a tendency to stop at the Last Step as expected. (P4) It was considered that there might be a difference between the rate of decrease from the 1st Step to the 3rd Step and the one in the 4th Step. (P4)

According to the proficiency difference, subject B and C had the same patterns of decreasing about time required except the Last Step. Subject A had the same pattern with subject B and C except under the condition of T-Slow of S-3/4 for 1st Step. Subject D had obviously different pattern from 1st Step to 3rd Step of S-3/4 compared to other performers.

4.3.2. The specification of the step to adjust change of the speed

In order to confirm where the change of the speed occurs, we researched the most decreased Step and the most increased Step by comparing each value with the previous step after calculating the rate of the time required per step to the total time. The most decreased rate of Step to the previous step is shown for each of 4 performers in Table 4.

Table 4 Step with the most decreased rate compared to the previous step

Time condition(T)	Slow Speed (1/2×Speed)		Nomal Speed (1×Speed)		Fast Speed (2×Speed)	
Spatial condition(S)	1/1 (3.0m)	3/4 (2.3m)	1/1 (3.0m)	3/4 (2.3m)	1/1 (3.0m)	3/4 (2.3m)
Subject A	2nd	3rd	2nd	2nd	2nd=3rd	2nd=3rd
Subject B	3rd	3rd	3rd	3rd	2nd	3rd
Subject C	2nd	3rd	2nd	3rd	2nd	2nd
Subject D	2nd	2nd	2nd	3rd	3rd	2nd

Unit: Step

It was confirmed that there was a tendency that the most decreased Step in the time required in the total performances (3 time conditions (T-Slow, Normal, Fast) × 2 spatial conditions (S-1/1, 3/4) × 4 performers = 24 performances) is the 2nd Step (13/24 perform 54.2%) or the 3rd Step (10/24 perform 41.7%). Especially, in spatial condition S-1/1, the 2nd Step tended to become the shortest (8/12 perform 66.7%). In S-3/4, the 3rd Step tended to become the shortest (7/12 perform 58.3%). On the other hand, the most increased Step compared to the previous step was the Last Step regardless of the condition for the area (24/24 perform 100%). From this result, we specified that the most decreased Step in the time required is the 2nd Step or the 3rd Step and the most increased Step is the Last Step. (P4)

4.3.3 Regularity for step in the decrease of the time required

Table 5 Logarithmic curve and R^2 value

Time condition	Slow Speed	Normal Speed	Fast Speed
Subject A	y = -0.076ln(x) + 0.3972 R^2 0.90	y = -0.084ln(x) + 0.435 R^2 0.99	y = -0.076ln(x) + 0.4519 R^2 0.97
Subject B	y = -0.093ln(x) + 0.4669 R^2 0.89	y = -0.09ln(x) + 0.4788 R^2 0.89	y = -0.085ln(x) + 0.4968 R^2 0.88
Subject C	y = -0.121ln(x) + 0.5798 R^2 0.93	y = -0.09ln(x) + 0.4728 R^2 0.94	y = -0.076ln(x) + 0.4557 R^2 0.66
Subject D	y = -0.146ln(x) + 0.6970 R^2 0.98	y = -0.155ln(x) + 0.7654 R^2 0.79	y = -0.138ln(x) + 0.7210 R^2 0.91

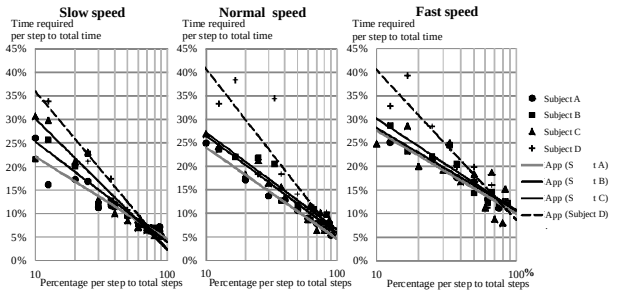


Fig. 5 Semi logarithmic graph where the percentage per step is set as x-axis

The process where the time required for step becomes shorter had the tendency that it decreased from the 1st Step to the 3rd Step and showed few changes after that. This decrease could not be expressed by linear function. Then we focused on the regularity in the decrease in the time required except for the Last Step. It showed the 2 different spatial conditions are added together (S-1/1+S-3/4) under the same time condition in Figure 5 by setting the percentage per step as x-axis by semi log graph. By approximating the data by log that set e (Napier's constant) as radix (Natural logarithm: hereinafter described as ln), we examined the possibility to

express the regularity of the decrease in the time required for step by using a function. The coefficient of ln gained and R^2 value as coefficient of determination (goodness of fit) is shown in Table 5.

As a result, we found that all 4 performers have the same patterns that changed the time required dynamically in the process of 2nd to the 3rd Step. The trend had high rate on the R^2 and it showed the trend of matching ln. We could say *Hakobi*'s acceleration except Last Step might show ln which had deficiency. About proficiency difference, the graph of subject B and C had a similar curve under the T-Normal condition. Therefore, we found this curve is expected as a standard. Subject A was a similar to the curve of subject B and C but subject D had another curve under the T-Normal and Fast conditions. Under the T-Slow, each performer had its own different curve.

Subject B and C had the higher rate of R^2 under T-Normal condition than the rate of other conditions. They showed the prod spread small. Subject A had the highest rate of R^2, it was extreme high, 0.99 under T-Normal condition. Subject D had a high rate under the T-Slow condition among them.

4.4. Analysis for the timing to step the foot forward (A4)

The gait of the 1st Step is shown in Figure 6. In Figure 7, calculation results for the time required for 1 step of *Hakobi* under the spatial condition S-1/1 (shown as the bar graph with a light color) and the timing for the next step (shown as the bar graph with a dark color) for each of 3 time conditions (T-Slow, Normal, Fast). In the bar graph with a dark color, when the value shown as ＊ is the + direction, it means legs do not move. When the value shows the － direction, it means the time which the next step is moving before the stop stepping (by putting down the toe) of the previous step.

As a whole, when we focus on the stepping forward, the next stepping forward was performed before the stop stepping of the previous step after the 4th Step. But when we focus on the stepping forward of the 2nd to 3rd Step by subject A and subject B shown as ＊ mark, the next stepping forward was started after the previous step was completed.

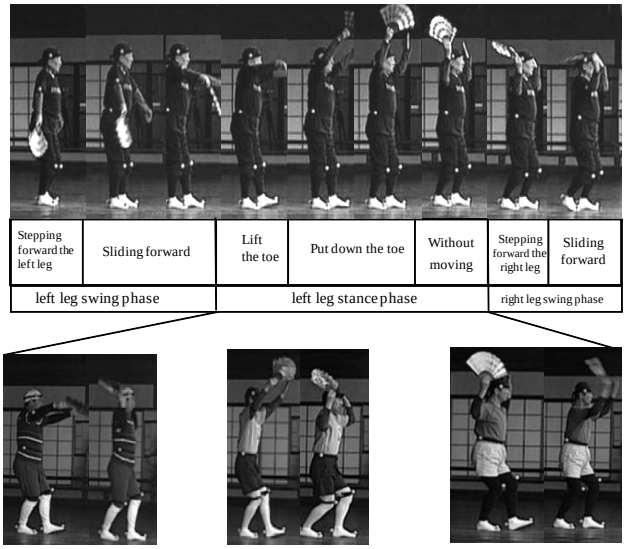


Fig. 6 Gait of the 1st Step of *Hakobi* at Slow Speed (The upper row: subject A, the lower row from the left: subject B, subject C, subject D)

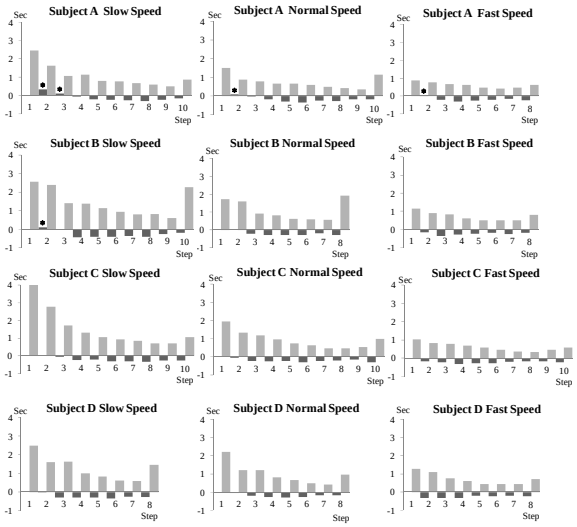


Fig. 7 Time required for each step of *Hakobi* and time from the front leg stop stepping to the next step starting

Thus, in order to confirm this tendency further, the time difference at the time of the stop stepping at the 1st Step and the stepping forward of the 2nd Step in the 24 performances in total (6 performances × 4 performers including the spatial condition of S-3/4) is shown in Table 6. When the value is ＋, it means that the 2nd Step was performed after stopping the 1st Step, and when the value is －, it means that the 2nd Step was performed before stopping the 1st Step.

Table 6 The time of the 1st Step and the timing of the stepping forward for 2nd Step

Time condition(T)	Slow Speed(1/2×Speed)		Nomal Speed(1×Speed)		Fast Speed(2×Speed)	
Spatial condition(S)	1/1	3/4	1/1	3/4	1/1	3/4
Subject A	0.333	0.759	0.099	0.264	0.003	0.099
Subject B	0.010	-0.528	0.000	0.066	-0.165	-0.363
Subject C	0.000	0.264	-0.066	0.165	-0.165	-0.132
Subject D	-0.003	0.000	-0.033	-0.033	-0.330	-0.132

Unit: sec

In Table 6, through 3 time conditions (T-Slow, Normal, Fast) and 2 spatial conditions (S-1/1, 3/4), both the styles of 2nd Step's timing to step forward after or before stopping the 1st Step were mixed, as seen in 10 performances shown in the dark color.

About the proficiency difference, subject B and C had a style that performed the 2nd Step started after stopping 1st Step under the T-Normal of S-3/4 conditions. It also had the same pattern under the T-Slow but didn't have under the T-Fast. Subject A had the same pattern under all conditions. Subject D didn't have any. From this view, we could expect the proficiency deference on the timing for starting sliding. (P5)

5. Discussion

By examining the results from the viewpoint of proficiency difference, we will review the specification of the step that changed the speed was extracted (E1) and the skills for speed adjustment (E2).

From the results of the time requirement (A1), when time condition (T) is adjusted to T-Slow: ×1/2 condition or T-Fast: ×2 condition, against the expectation that the time used for *Hakobi* might be equally proportionate, the results were found to become close to *Hakobi* under T-Normal condition for 4 performers in common.(P1) Subject D had the tendency to make the rate for the change of the speed smaller compared to the subject B and C. Especially it was considered that the performance at the Slow Speed has a high degree of difficulty compared to the one at the Fast Speed. The hypothesis that the performance at the Slow Speed has a high degree of difficulty corresponds to the results that the mastering of the low speed on average has a high degree of difficulty, in the research regarding the developmental processes for *Ko-Mai* of *Kyogen* [22]. Additionally, it also corresponds to the research that it is difficult for infants as well to master slow movement and tempo in the process of learning the movements or tempos [23].

From the results for the number of steps (A2), it seemed that there was a tendency that the number of steps increases or decreases proportionately for 4 performers in common. (P2) However, it was also found that there was hardly any difference between subject A under T-Normal and T-Fast conditions and subject D under T-Slow condition despite the difference in the area. From this, we found that there are some cases where the adjustment for *Hakobi* might be made not only by the number of steps but also by the length of the steps. (P3) This indicated that it was different from the result of *Geidan*, that was always performed with the same steps on the same distance [3].

From the results that examined the time ratio of each step among the total time (A3), we took the same result as the expectation that the performer reduced his speed and stopped at the Last Step after 2 patterns of accelerations. (P4) Through these results for the Last Step, we identified the research [19]. 2 patterns were considered to be separated from the 1st Step to the 3rd Step and the one after the 4th Step. Therefore, we assume "*Jyo*" as from the 1st Step to the 3rd Step and "*Ha*" as the one after the 4th Step. In short, the speed was accelerated at 1st to the 3rd Step, became top speed at the 4th Step and kept the top speed until stopped stepping at the Last Step by *Hakobi*. These results were corresponded to the explanation talked about the movement from "*Jyo-Ha-Kyu*" in *Geidan*. After we also focus on the characteristics where there is a big changing point from the 2nd Step to the 3rd Step and examined the possibility to show the regularity of the change of the speed for the step from "*Jyo*" to "*Ha*" by utilizing log, we found the possibility to show by natural logarithm (ln). Subject B, C and A had the high rate of R^2 under Normal Speed condition. From these, we found that the process of *Hakobi* from "*Jyo*" to "*Ha*" is natural to consider the continuous changes and that the pattern for the changes have characteristics to raise the rate to correspond to natural logarithm (ln).

From the results of the timing to step the foot forward (A4), when performing *Hakobi* where the

speed changed greatly from the 2nd Step to the 3rd Step, we found that there was special skill that was thought to be related to the timing of stepping forward of the 2nd Step and the 3rd Step. That means the skill to step forward after stopping the previous step. (P5) This skill appeared in the 2nd Step frequently. Subject B and C had it under 2 conditions and subject A had it in every conditions. But Subject D didn't have any. With this fact, the skill is correspondent to proficiency difference. This result significantly reflects when these performers start their training. In the research regarding the characteristics of the movements for the 2nd Step in Dance, there is a research about *Nihon Buyo* [24] that the slowness in progressing the 2nd Step represented the femininity. Moreover, in the research regarding the timing to step forward the 2nd Step when performing the representative activities subject to *Kyogen* performers and *Kyogen* learners [19], there was a tendency that corresponded to the research that the stepping forward for the 2nd Step by *Kyogen* performers was later than that of *Kyogen* learners. So, this research reports "this tendency produced "*Tame*" ※3 which is the characteristics of the movements for *Kyogen*". However, it is understandable that the skill to step forward after stopping the previous step gained by this research should be one of the skills that produce "*Tame*" mentioned as the characteristics of the movements for *Kyogen* as well.

These results show that the speed is accelerated on the 2nd Step or the 3rd Step, and decelerate on the Last step (E1). Regarding the skills for speed adjustment (E2), we found that there is a skill to adjust by the length of the step as well as by the number of steps in order to adjust spatial condition (S). And there is also a skill for "*Tame*" to delay the stepping forwards of the leg in the 2nd Step or the 3rd Step. By utilizing these skills to produce rhythm and tempo, "*Jyo-Ha-Kyu*" of *Hakobi* has been produced. Especially, it was found that the process from "*Jyo*" to "*Ha*" among "*Jyo-Ha-Kyu*" has the possibility to have a series of flow with regularity according to ln.

We discuss why Kyogen performers need to start their training from their childhood to gain the skill of "*Jyo-Ha-Kyu*" in *Hakobi*. Regarding acquisition of the movement "*Tame*", we analyzed the researches for the skills for offense in basketball in the sports movements [25], or there is "*Ma*" for the posture in the air to reserve grounded legs for stepping forward for the experts of standing quintuple jump competition [26] and there is a research for the methods to practice for the acquisition process. Besides, research regarding the tempo for the steps, there are some study groups for the skills for jumping competition in athletics, such as long jump[27],[28], jumping ability [29]. In these researches, by examining proficiency difference and the characteristics of the movement, they try to acquire the training which improves the records. Actually, it is reported that the movements such as "*Tame*" have been acquired by the training for a certain period.

Additionally, regarding the process of the acquisition of skillfulness for the exercise since childhood, there are a lot of study groups that adopt the movement for running [30], continuous jump with one leg [31], the movement for throwing [32] or the movement for jumping [33]. In these researches, it is reported that the acquisition of the exercise is in proportion to the period of the significant development of the nervous system and the exercise would be acquired mostly by the age of 7 to 11[31],[34],[35] .

On the other hand, when examining the research where the time of initiating and the ability of music by understanding the rhythm of "*Jyo-Ha-Kyu*", from the research where the age when the training was initiated and the cortical area that influences exercise in the brain [36], and the degree of relationship between the exercise of fingers or the improvement of the skills for auditory sensation [37], were examined, it is reported that there is a big difference in the performances and also a structural difference of cortical spinal tract in brain between over 7 years old or under 7 years old [38]. In short, the training for music is thought to be useful to start the training by the age of 6 years old from the viewpoint of plasticity of the brain [37].

As mentioned above, to acquire the skill with the factor of rhythm and music tempo requires their early start of training. Therefore, we can interpret Living national treasure's words "we cannot acquire the skills of *Hakobi* as "*Jyo-Ha-Kyu*" unless we start the training from our childhood." as "*Jyo-Ha-Kyu*" in *Hakobi* includes the factors of rhythm and music tempo in

addition to the kinematic factors.

6. Conclusion

In this research, we analyzed *Hakobi*. *Hakobi* the sliding walk is one of the representative performance skills in Japanese traditional performing arts. It is important especially in *Hakobi* of *Nohgaku* to perform along with the rhythm called "*Jyo-Ha-Kyu*". Regarding the rhythm for "*Jyo-Ha-Kyu*", we could see variously explained by *Geidan* (talk on the arts). So it is said that it is impossible to master *Hakobi* with the rhythm of "*Jyo-Ha-Kyu*" unless the training was started since childhood. Then, with 4 *Kyogen* performers including an expert (Living national treasure) as a target, we decided to record *Hakobi* with "*Jyo-Ha-Kyu*" performed on *Noh* stage and analyze it. For implementation, we set time conditions and spatial conditions variously and tried to clarify the skills for *Hakobi* quantitatively by using proficiency difference as a clue. In the previous studies for proficiency difference, the number of years or history of awarded prize would be used for the identification of proficiency in many cases. However, in this study, we examined from the standpoint of the identification whether the training was started from childhood. From these discussions, we succeeded to explain the rhythm of "*Jyo-Ha-Kyu*" quantitatively. The main results gained are as follows.

1) We found the skill to perform the adjustment of the speed; the 2 existing skills, the ability to adjust the length of the step and the skill for "*Tame*" that delays the timing to step forward.

2) According to setting the musical conditions experimentally as Slow Speed (×1/2) and Fast Speed (×2), spatial condition as narrow (×3/4), we found tendency that the value became close to the one at the time of Normal (1/1) rather than the one that is proportionate in the calculation in 4 performers commonly. Especially, under musical condition, the proficiency difference appeared most clearly at the time of adjustment under Slow Speed (×1/2) condition.

3) Among "*Jyo-Ha-Kyu*", "*Kyu*" would be performed at the Last step. Regarding "*Jyo*" and "*Ha*", we found that 2nd Step to the 3rd had changes point of the speed. Moreover, we found the pattern of the change from "*Jyo*" to "*Ha*" had regularity following natural logarithm (ln).

4) From the previous researches, it was acquired that the skill with the factor of rhythm and music tempo requires their early start on training. Therefore, we can interpret Living national treasure's words "we cannot acquire the skills of *Hakobi* as "*Jyo-Ha-Kyu*" unless we start the training from our childhood." as "*Jyo-Ha-Kyu*" in *Hakobi* includes the factors of rhythm and music tempo in addition to the kinematic factors.

We would like to promote the study to utilize this skills for adjustment acquired in this research, at the actual field of *Kyogen* performing.

Comment

1. Living national treasure is the person who is approved as holding Intangible Cultural Properties designated by Minister of Education, Culture, Science and Technology. There are 3 *Kyogen* performers designated as Living National Treasure as of April 2014.

2. *Ko-Mai* is dance performance of *Kyogen*. It used as the educational material for physical training for *Kyogen* performers and also performed on the real stage [3]. The dancer performs his dancing for 1～3 minutes with *Ko-Uta* (which is sung by the *Ji-Utai* performer) after the dancer (who is singing the first phrase) standing up from the position with one sitting on the nee. In this research, each performer danced along with the music of DVD (Kyogen of Yamamoto Tojiro: Masuda and Yamamoto Editor., Manufactured by Japan Traditional Cultures Foundation., Distributed by Victor Entertainment, INC., JAPAN, 2007) without singing by himself .

3. "*Tame*" is skill of little delay in time called "Ma" before performing next movement or next music performance.

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Abstract（Japanese）

目的：日本の伝統的芸能全般において代表的な演技技法の一つであるすり足歩行＝ハコビの序破急のリズム展開を定量的データによって説明することを目的とした．

方法：対象は人間国宝を含む4名の狂言役者であった．ハコビの時間的条件（T）と空間的条件（S）を実験的に様々に設定し，彼らのハコビの映像を記録した．得られた映像から所要時間（A1），歩数（A2），ステップごとの所要時間（A3），足を踏み出すタイミング（A4）を分析し，そこから速度変化の調整を行うステップ（E1）と調整の技（E2）について調べた．

結果：次の3つの技を特定できた．1；速度変化の調節を行うステップ（E1）は，加速では2nd Stepまたは3rd Step，減速ではラストステップである．2；調整の技（E2）には，歩数のみならず歩幅で空間の広さを調整する技がある．3；ある条件が整う場合には，2nd Stepまたは3rd Stepに足の踏み出しを遅らせる技がある．これらの技を用いてハコビの序破急のリズムとテンポが生み出されていることがわかった．特に序から破への展開は，自然対数によって高い精度で近似できた．

結論：ハコビに序破急のリズム展開を加える難しさは，序から破への速度変化を自然対数に近似したリズムの規則性に則り体現することにあると示唆できた．

Key words：序破急，狂言，巧みさ，熟達差，伝統芸能

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専門は動作学．狂言役者の呼吸パターンやハコビの分析など，特に芸能の身体技法に焦点をあてた研究を行っている．