Motion Analysis of Interval Time During "Kana-ami" Making Process

Zelong Wang[1(✉)], Ken-ichi Tsuji[2], Toru Tsuji[2], Yuka Takai[3], Akihiko Goto[3], and Hiroyuki Hamada[1]

[1] Advanced Fibro-Science, Kyoto Institute of Technology, Kyoto, Japan
simon.zelongwang@gmail.com
[2] Kana-ami Tsuji, Kyoto, Japan
tsujiken@kanaamitsuji.com
[3] Department of Information systems Engineering, Osaka Sangyo University, Osaka, Japan
gotoh@ise.osaka-sandai.ac.jp

Abstract. In this paper, the motion making technique of Japanese traditional handicraft was analyzed by motion analysis system. Two experts were employed as expert and non-expert for comparison. The feature of interval time for each main work process was paid attention. The subjects' interval timing during the weaving process was clarified to investigate the proficiency of weaving technique quantitatively. It is found that expert was able to go into working state easily.

Keywords: Kana-ami · Interval timing · Motion analysis · Expert · Non-expert

1 Introduction

"Kana-ami" is a classical traditional handicraft product of metal wire network in Japan as shown in Fig. 1. It's employed as one kitchen instrument (tofu scooping) or fence knitting for cultural relic, which was once prevailed many years ago in the old Japan and has been decreased in the development of social industrialization. Additionally, traditional handcrafts are handed down mainly through oral teaching and extempore creation, making proceed of teacher-student relations, family relations and art education.

However, it is very difficult for learner to copy the weaving motion from master. Usually, the master only can pass the every essential to the prentice but the rest were on your own. Therefore, the technique of tradition handcrafts is reliant on apperceiving heavily as "Kana-ami". Without apperception, it cannot be learnt no matter how hard you study, which was considered as the special tacit knowledge. And quantified the correct apperception of master is the main target in this study.

In previous research, the expert's motion of the "Kana-ami" weaving process was clarified, which was "brief, frequent, fast" during the twisted cross [1–3]. As the same time, the different "Kana-ami" hexagonal structure in vertical direction between expert and non-expert also was explained in the free fall experiment by high-speed camera [4, 5]. The metal wire net of "Kana-ami" made by expert presented the convex shape in vertical direction so that helps buffer the fall. The results confirmed the superiority of the product made by expert.

V.G. Duffy (Ed.): DHM 2015, Part I, LNCS 9184, pp. 201–211, 2015.
DOI: 10.1007/978-3-319-21073-5_21

Fig. 1. The Japanese traditional handicraft of “Kana-ami”

Refer to the previous conclusions, the reasonable decoding and the effective expression of expert’s motion were focused in this research. The motion analysis system was applied, through extracting each main work of twisted cross during the “Kana-ami” weaving process, both expert and non-expert’s fingers trajectory of twisted cross was recorded and separated base on there-dimensional coordinate system. The velocity, acceleration, and jerk were also calculated as the same time, in order to further analysis the feature of motion between expert and non-expert.

As well know, the hardest part about movement for a learner is the motion changing moment, which the velocity and direction of movement generated uncertain changing. However, every movement changing has to experience a process of acceleration direction changing, which was jerk value around zero as called interval-timing moment in this research.

In additionally, the interval-timing of each twisted cross was found and summarized. The characteristics of interval timing for expert and non-expert were compared. It was discovered that the expert’s interval timing of each weaving process was reduced gradually as the weaving progresses. It is means that expert was able to enter the working state quickly, and change every movement essential with short interval timing.

The purpose of this paper was through motion analysis to clarify the interval-timing between expert and non-expert’s motion in order to find a current movement technique of “Kana-ami” weaving method.

“Kana-ami” was all made by hand work, so the processing motion technique makes a big effect on final products’ quality and craftsman’s long-term working efficiency.

2 Experiment

2.1 Participants

In this study, the two masters with 46 years and 10 years wire netting technique experience were employed as participants, which called expert and non-expert. The expert and non-expert not only have parent child relationships but also have mentoring relationship. And both of them would be committed to heritage this Japanese handicraft technique of ‘Kana-ami’.

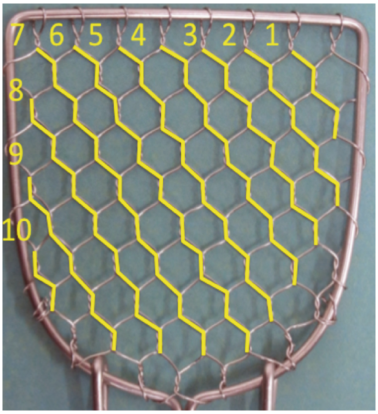

Fig. 2. Metal wire network pattern of 'Kana-ami' product

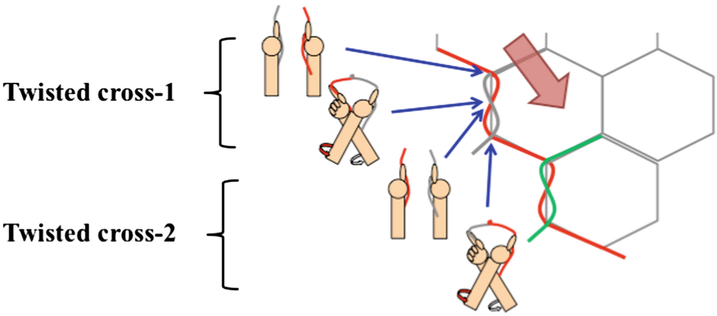

Fig. 3. The two main twisted crosses process of hexagonal pattern

2.2 Weaving Procedure

The subjects were required to make a "Kana-ami" product. Figure 2 shows a photo of one of completed samples. The hexagonal pattern was started and twisted from 1st oblique row to 10th oblique row according to weaving order. Figure 3 was illustrated a schematic detailing the making process of a hexagonal pattern of wire network. As shown in Figs. 2 and 3, the "Kana-ami" product was consisted by 48 hexagons, which were established by two twisted crosses on both sides. Therefore, the weaving process of two twisted crosses was the main work during the whole "Kana-ami" weaving process. As shown in Fig. 3, the first twisted cross was called as "Twisted cross-1" and the second twisted cross was called as "Twisted cross-2". The "Twisted cross-1" and "Twisted cross-2" were paid attention in this paper.

2.3 Experimental Process

The three-dimensional motion capture system was used for evaluating the motion of making wire nets. (Hawk-I; Motion Analysis Co. Ltd.) The infrared reflection markers were affixed at 21 points on the body of the subject to analyze motion during the wire netting as shown in figure. And six cameras captured the position of each marker in the X, Y and Z directions with 100 Hz sampling rate. All markers position data were synchronized and entered into a computer. All subjects (10 products) were recorded under the former predetermined condition as shown in Fig. 4.

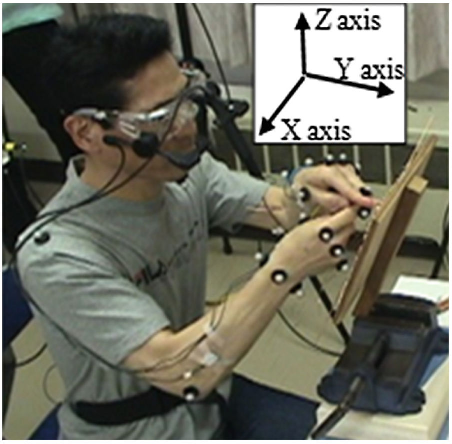

Fig. 4. The measurement setting of motion analysis

2.4 Interval-Timing Analysis

The data of expert and non-expert's motion during the period of each twisted cross was extracted from the motion analysis system. The motions were categorized into 4 types according to the finger and twisted cross as shown in Fig. 5, which were called as

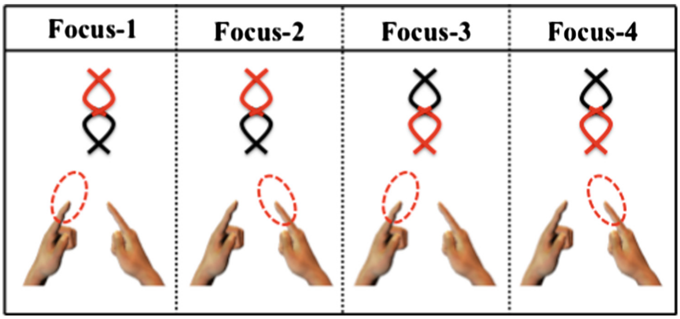

Fig. 5. Focus illustration of interval-timing process

“Focus-1”, “Focus-2”, “Focus-3”, “Focus-4”. As shown in Fig. 5, the “Focus-1” was focused on the left index finger during the process of “Twisted cross-1”, the “Focus-2” was focused on the right index finger during the process of “Twisted cross-1”. And the “Focus-3” and “Focus-4” were focused on the left and right index fingers during the process of “Twisted cross-2”.

All the acceleration changing moment of four types data was found, which the jerk value around zero, which also was the acceleration direction of transient variation. The interval-timing was defined as a period in the range of the average acceleration changing when the jerk was around zero. One “Kana-ami” product has 48 hexagons consisted of 70 times trials of two twisted crosses. The motion of “Focus-1” at the first hexagon on 2nd oblique row by non-expert was presented as an example, whose velocity, acceleration and jerk were shown in Figs. 6, 7 and 8. The interval timing

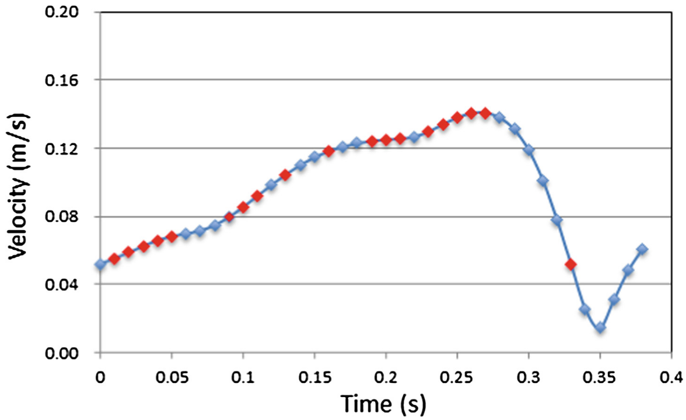

Fig. 6. An example of interval-timing plot on velocity figure

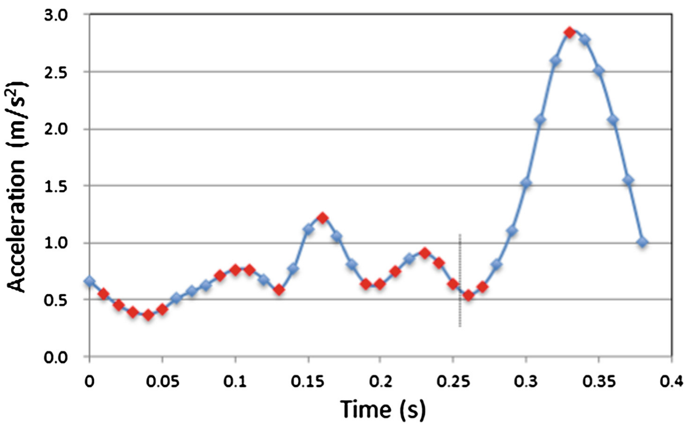

Fig. 7. An example of interval-timing plot on acceleration figure

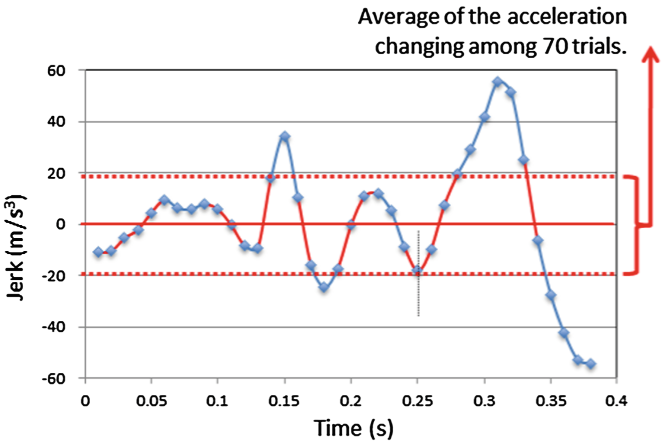

Fig. 8. An example of interval-timing plot on jerk figure

moments on the range of average acceleration changing moment was found out as red marks in Fig. 8. Accordingly, interval-timing moment of the velocity and acceleration were illustrated as red marks on the Figs. 6 and 7. Therefore, in the example case, the number of interval timing was eight, and the average time for each interval-timing for this trial was 0.026 s. And the whole time of example trial was 0.39 s, the percent between interval-timing and whole time was 53.85 %. It is means that 53.85 % time was used to prepare for changing motion.

3 Result and Discussion

The number of interval-timing, average time of interval-timing, and the percent between interval-timing and whole time for 70 trails were summarized according to the four types focus ("Focus-1", "Focus-2", "Focus-3", "Focus-4"), which illustrated into Figs. 9, 10, 11 and 12 respectively.

According to the four types focus, it easy can found that the percent of interval-timing of expert and non-expert was around 40 %. That was means that both expert and non-expert had to spent around 40 % time to prepare for changing motion during each weaving process of twisted cross. And the number of interval-timing in each trial was reduced gradually as the weaving progresses. And the time of each interval-timing also was reduced as the same time. It can be said that, in case of expert, the prepare time for motion changing was reduced under the same condition of the effective movement. The weaving efficiency was also improved gradually. However, in case of non-expert, both the number of interval-timing in each trial and the time of each interval-timing was keep a same range during the whole weaving process (70 trials). Expert was not able to enter the working state, and change every movement essential quickly.

In a word, it was can considered that the three-dimensional velocity changes need successively through the process of vector acceleration and deceleration. It is has to

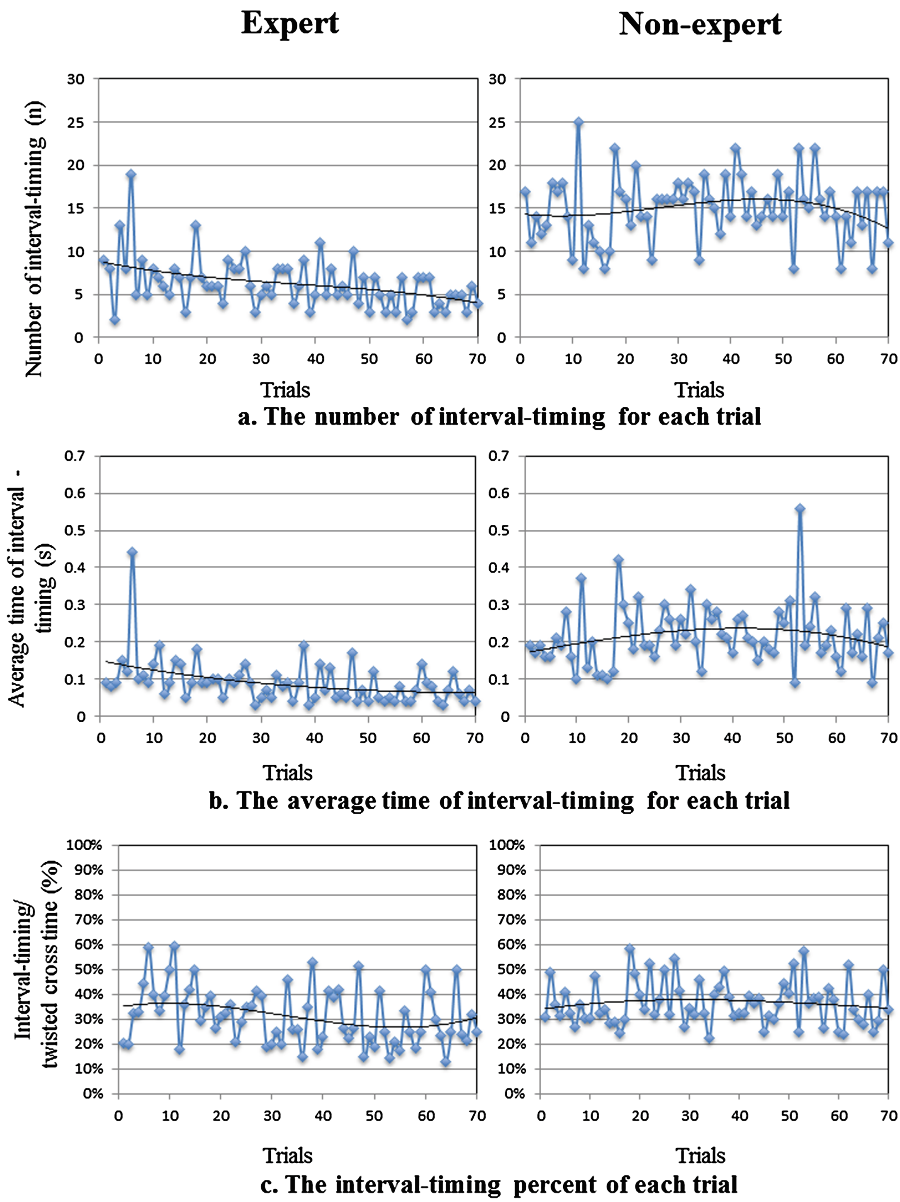

Fig. 9. "Focus-1" comparison between expert and non-expert

take a short process of uniform acceleration when the acceleration direction was changing, because the behavior motion completely controlled by the brain and requires action time. Therefore, the interval-timing was an important feature of motional proficiency.

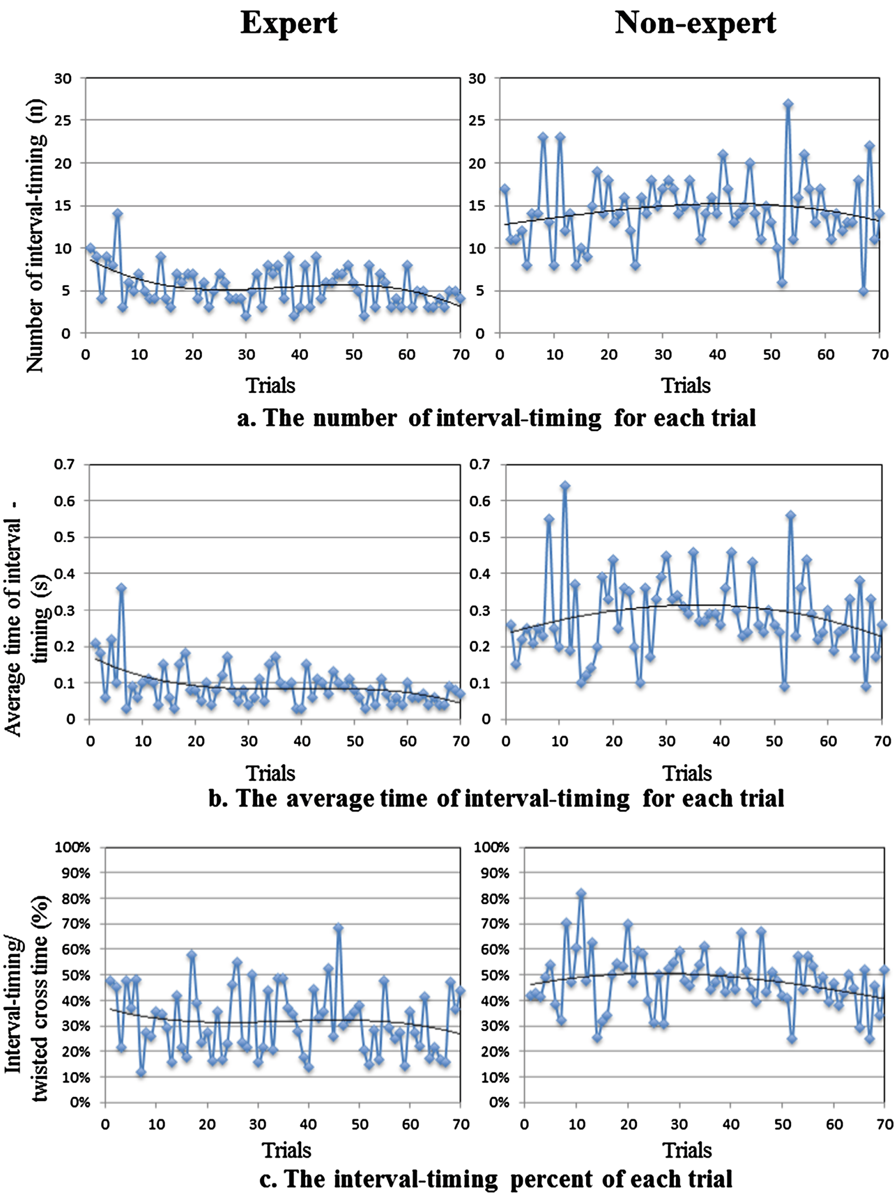

Fig. 10. "Focus-2" comparison between expert and non-expert

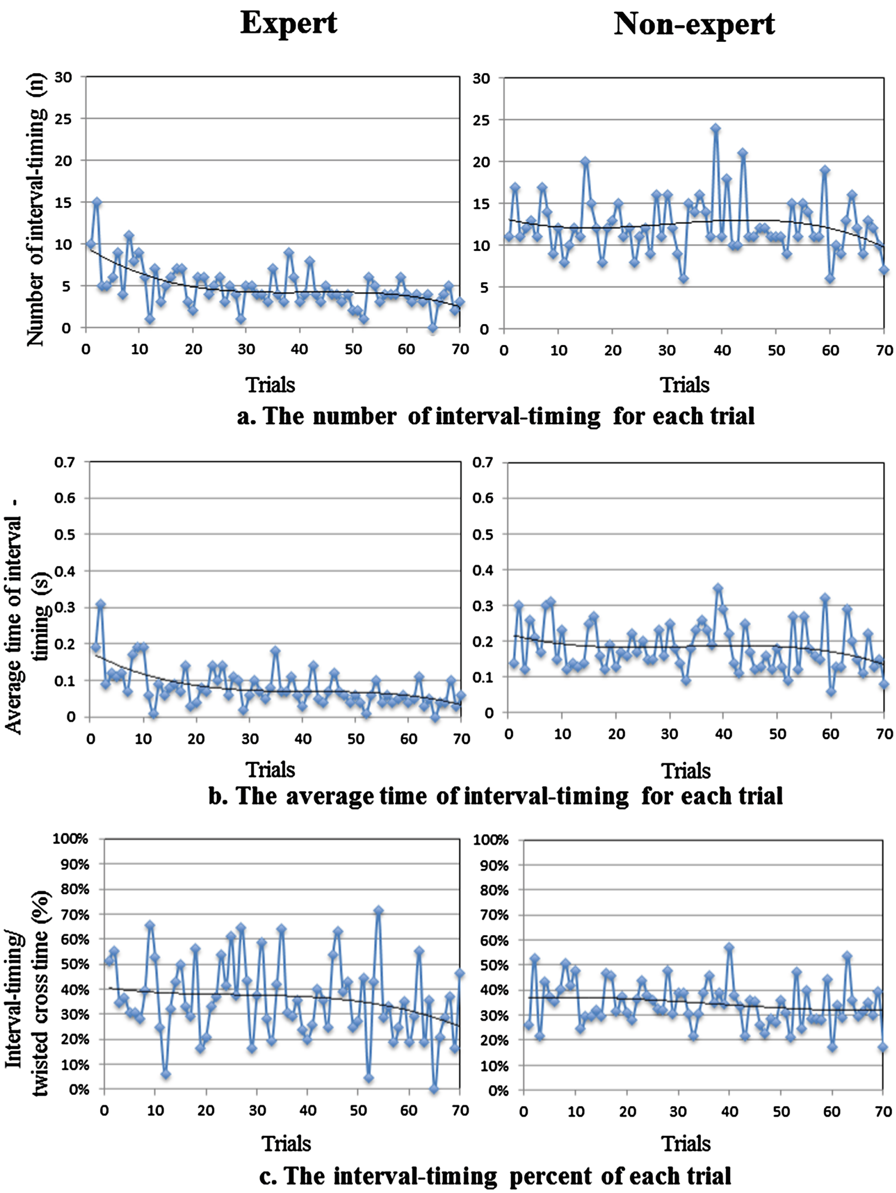

Fig. 11. "Focus-3" comparison between expert and non-expert

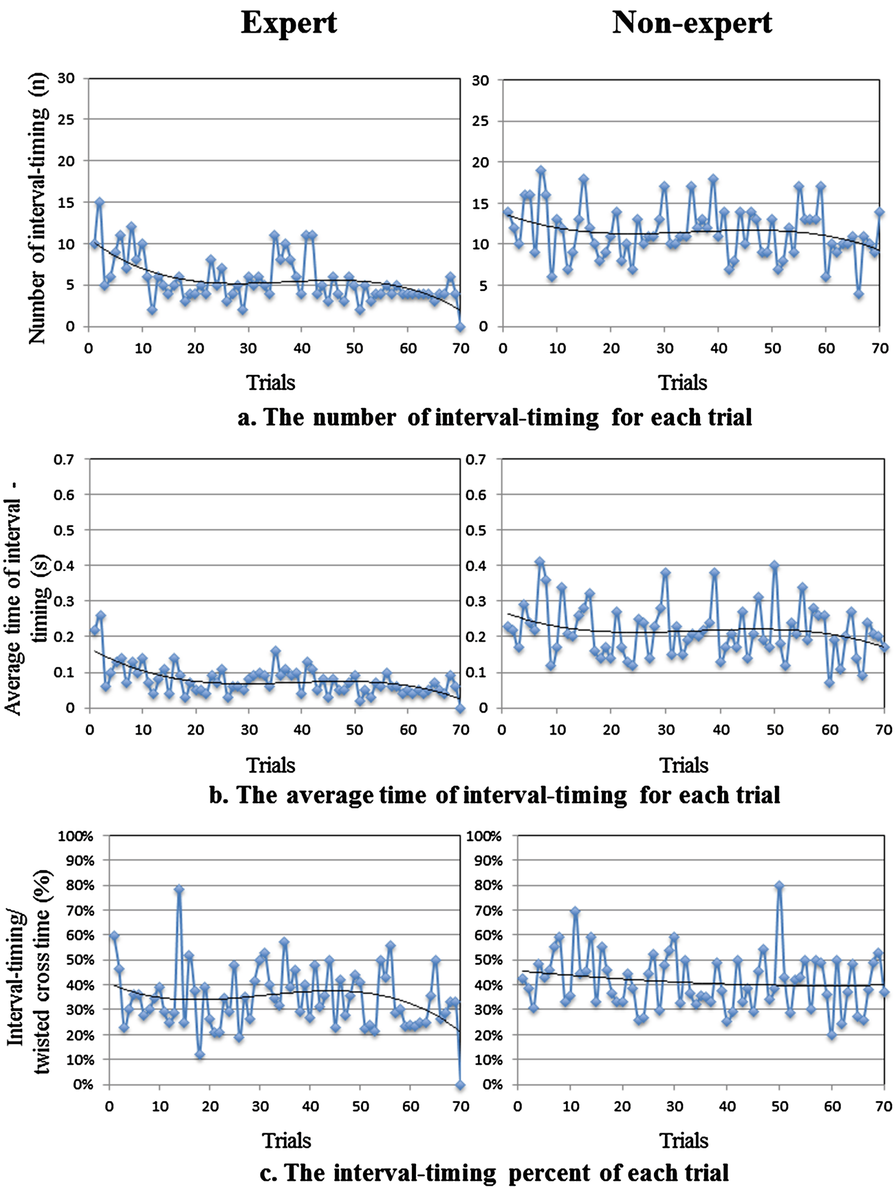

Fig. 12. "Focus-4" comparison between expert and non-expert

4 Conclusions

As a conclusion, both expert and non-expert spent round 40 % time to make interval timing movement for each trial. Because the number and time of “Interval-timing” was reduced gradually in case of expert, the completion time of each weaving trail was shown significant reduction. It is can considered that expert can change motion state skillfully, and easier to enter a right working state smoothly.

References

1. Tusji, K., et al.: Motion analysis of weaving ‘Kana-ami’ technique with different years of experience. In: Proceedings of ASME 2012 International Mechanical Engineering Congress & Exposition, ASME (2012)
2. Tatsunori, T., et al.: Motion Analysis of the Technique Used to Knit Kanaami. In: symposium on sports engineering: symposium on human dynamics, pp. 258–261 (2007)
3. Tatsunori, T., et al.: Human motion of weaving ‘Kana-ami’ technique by biomechanical analysis. In: Proceedings of 10th Japan International SAMPE Symposium & Exhibition, TC-1-3 (2007)
4. Wang, Z., Endo, A., Koshino, T., Tsuji, T., Tsuji, K.: Evaluation of metal wire network “Kana-ami” structure between expert and non-expert. In: Proceedings of ASME 2013 International Mechanical Engineering Congress & Exposition, ASME (2013)
5. Wang, Z., Tsuji, K., Tsuji, T., Goto, A., Takai, Y., Yang, Y., Hamada, H.: Analysis on the three-dimensional wire orientation of “Kana-ami” metal network between expert and non-expert. In: Proceedings of ASME 2014 International Mechanical Engineering Congress and Exposition, ASME (2014)