SICE Annual Conference in Sapporo, August 4-6, 2004
Hokkaido Institute of Tecnology, Japan

Two Types Dynamics in Negative Asynchrony of Synchronization Tapping

Kouji Takano[1], Yoshihiro Miyake [1]
1 Tokyo Institute of Technology, G3-822 4259 Nagatsuta, Midori, Yokohama 226-8502, Japan
takano@myk.dis.titech.ac.jp

Abstract: In synchronization tapping task, Negative asynchrony is known as important matter to analyze human time perception. The system of negative asynchrony is suggested that there are two systems. In this article, we analyze the systems using a controlled SE and a controlled attention. As a result, it is proposed that one system use an attention and the other is not.

Keywords: Negative Asynchrony, Synchronization Tapping, Synchronization Error

1. Introduction

Time perception is a fundamental capability.

However, since, unlike other senses, the time perception system has no exclusive receptors. The system cannot be distinguished from the other senses. Then, how does human perceived time?

Human time perception has been a topic of research since early times[1]. Mainly, behavioral analysis has been used to perform these studies[2].

Recently, Human time perception has been analyzed using modern technology of brain imaging[3]. Although, a complete model of time perception has not been produced yet.

In former studies, an interesting phenomenon is known is continuous synchronization tapping task. In a continuous synchronization tapping task, the subject has to synchronize its taps with external repetitive events. This phenomenon proves an asynchrony between actual and perceived time and the phenomenon is called "Negative Asynchrony"[4].

Miyake and others have suggested that at least two systems exist. These systems generate negative asynchrony[5]. They proved that one of systems used attention and the other does not.

Fraisse proposed a hypothesis of a system that causes negative asynchrony[6]. Fraisse described that the only factor of negative asynchrony is time difference between signals from different senses.

However, no other models exist to explain the system of negative asynchrony. So, the only one system that causes negative asynchrony is proposed.

In a continuous synchronized tapping task, the inter stimulus onset interval (ISI) has been used as controlled parameter mainly[7]. The ISI is one of main parameters in the continuous synchronization tapping task. Other parameters are the inter tap onset interval (ITI) and the synchronization error (SE)(Fig.1).

Using the ISI as controlled parameter, to analyze the relation between ISI and SE is easy. However, to analyze the relation between SE on actual and on perceptive is difficult.

So, in our experiment, the time difference between tap and stimulus (SE) was controlled.

This new method makes it possible to observe the effect of time difference between tap and stimulus (SE) on the subject's action (ITI). Therefore we propose that it is possible to observe the effect of time difference between tap and stimulus on the subject's time perception.

In addition, as discussed above, a system using attention was suggested. Therefore, two trial conditions were examined in our study because of investigation of the system using attention in this new method. One was only a synchronization tapping task. The other was a synchronization tapping task with silent reading.

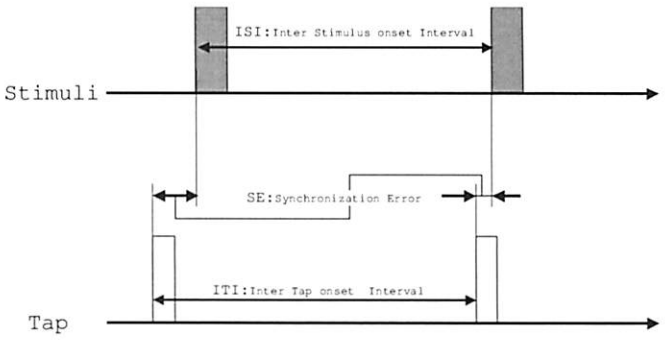


Fig.1 parameters in continuous synchronizing tapping task

2. Method

2.1 Task

Subjects were instructed to synchronize their taps with auditory stimuli as precisely as possible. The auditory

PR0002/04/0000-1792 ¥400

stimuli were presented periodically. Subjects tapped with their right index finger and they closed their eyes. The trials were operated in a quiet room.

2.2 Procedure

One trial constructed by 60 taps. Auditory stimuli were presented by difference procedures in the first 20taps and in the second 40 taps.

In the first 20 taps, auditory stimuli were presented periodically (ISI fixed condition). This procedure is the same as a procedure of typically continuous synchronization tapping task. In this condition, SEs vary with subject's taps.

In the second 40 taps, auditory stimuli were presented after subject's taps (SE fixed condition). Time difference between the subject's taps and the auditory stimuli were fixed through each trial. In this condition, SEs do not vary with subject's taps.

In the first 20 taps, 5 kinds of time lengths were used as the inter stimulus onset interval (450, 600, 900, 1200, 1800). In the second 40 taps, 7 kinds of time lengths were used as the synchronization error (0, -10, -30, -50, -70, -90, -110).

In addition, to investigate the relation between an attention and negative asynchrony, two conditions were examined. One is a normal condition. This condition is the only synchronization tapping task. The other is a reading condition. This condition is a synchronization tapping task with a silent reading.

2.3 Subjects

In each condition (normal condition and reading condition), 6 healthy men cooperated as volunteer. Their age was 20's–30's. All subjects were right handed. All subjects practiced in a continuous synchronization tapping task through other experiments.

2.4 System

This task was run on a PC laptop. Auditory stimuli were presented through a headphone connected PC. The duration of auditory stimulus is 100ms, the frequency is 500Hz, and the sound pressure is suitable for listening.

Subject's taps were recorded through a parallel port. The onset time of taps and stimulus were recorded on PC. A time precision was set in 1/2048s.

3. Result

3.1 Temporal development of ITI

In the second 40 taps (SE fixed condition), Three types of ITI behaviors were observed (Fig.2). One decreases (Fig2a). The other is stable (Fig.2b). And the last increases (Fig2c).

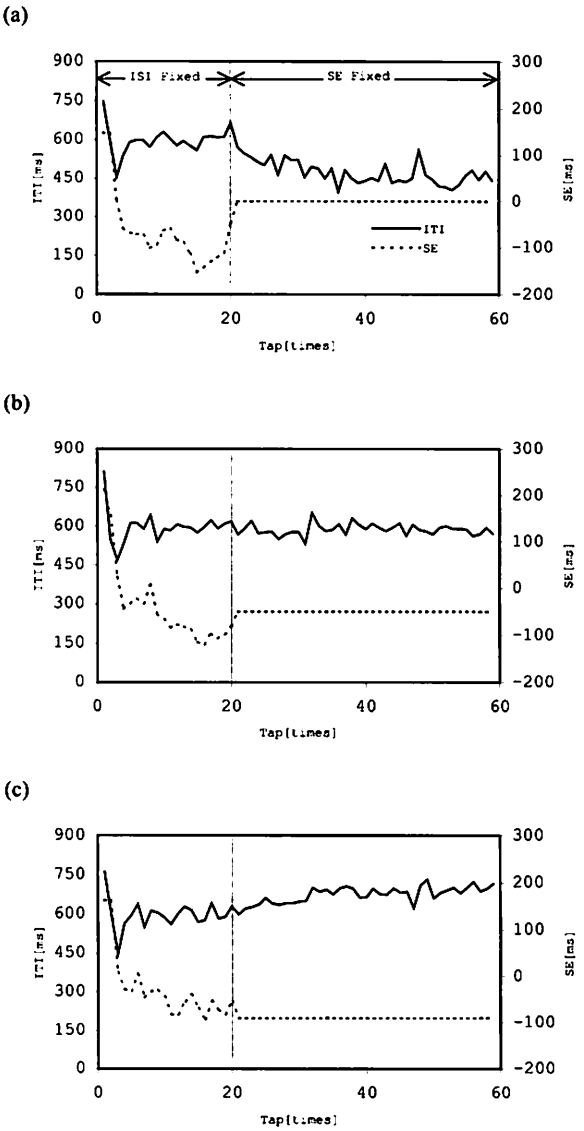
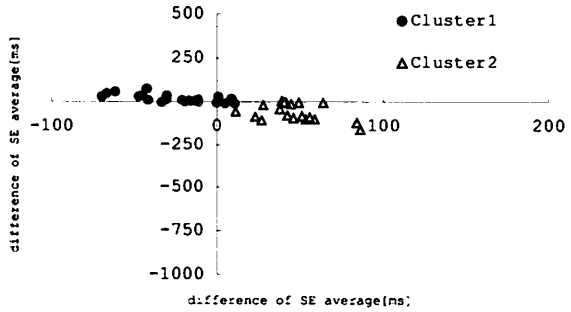
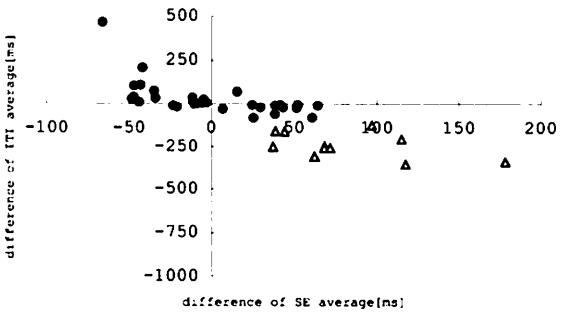


Fig.2 Temporal development of ITI and SE

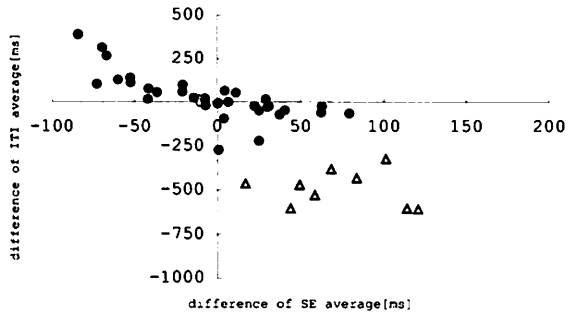
(a)ISI450



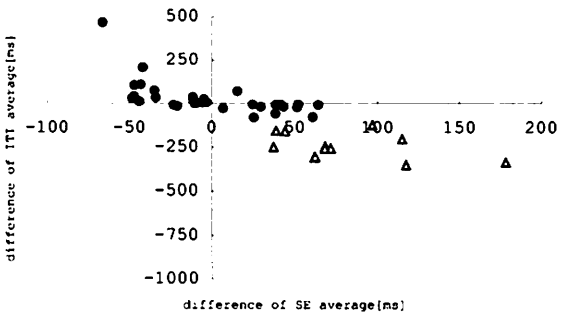
(b)ISI600



(c)ISI900



(d)ISI1200



(e)ISI1800

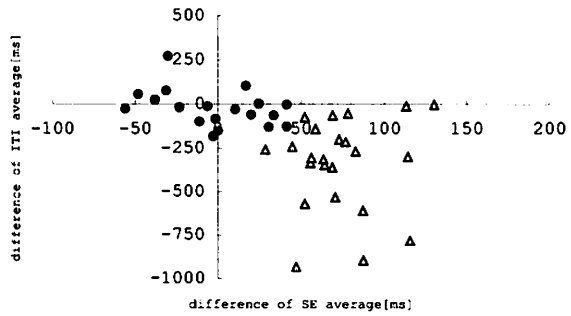


Fig.3 Scatter graph of difference of SE average and difference of ITI average in normal conditions

Table 1 Correlation coefficient between difference of SE averages and difference of ITI averages in normal conditions

ISI	Cluster1	Cluster2
450	-.619	-.598
600	-.619	-.406
900	-.732	-.127
1200	-.862	-.237
1800	-.392	.069

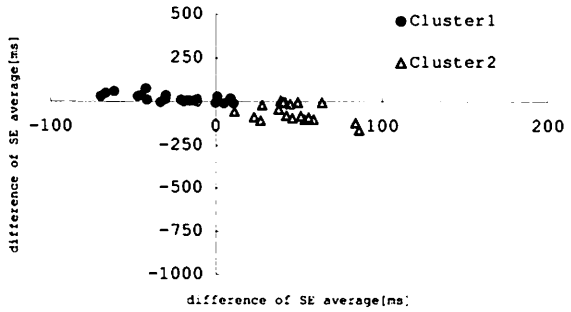
3.2 Relation between a difference of ITI average and a difference of SE average.

We investigated whether there is the relation between a fluctuation of SE and an ITI in a normal condition. So, a difference between an SE average of the first 20 taps and an SE average of the second 40 taps were used as horizontal axis. The difference between an ITI average of the first 20 taps and an ITI average of the second 40 taps were used as vertical axis (Fig.3). The correlation coefficient between the difference of an SE average and the difference of an ITI average was shown in Table1. The horizontal origin is a SE average of the first 20 taps. So, this origin means no time difference between a subject's tap and a presented stimulus on a subject's perception.

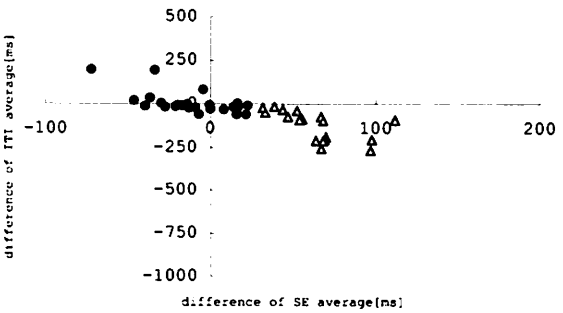
These data were categorized to two clusters according to a clustering method. The method, Ward method was used. Standardized squared Euclidean distance was used as dissimilarity. In what follows, one cluster which contains data on a second quadrant mainly. It is described as cluster1. The other which contains data on a fourth quadrant mainly. It is described as cluster2.

In case of ISI <= 600, each cluster has a high correlation coefficient between the difference of ITI average and the difference of SE average (Fig.3a,b, Table1). In case of ISI >=900, cluster1 has a high correlation coefficient. However, cluster2 has a low correlation coefficient (Fig.3c,d,e, Table1).

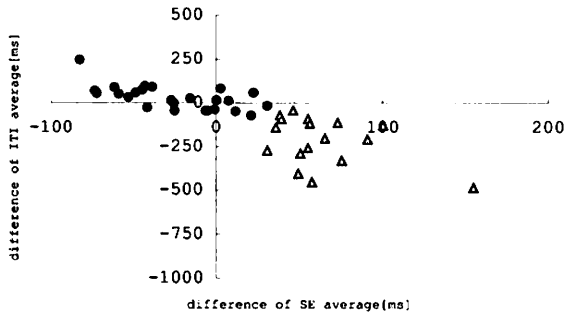
(a)ISI450



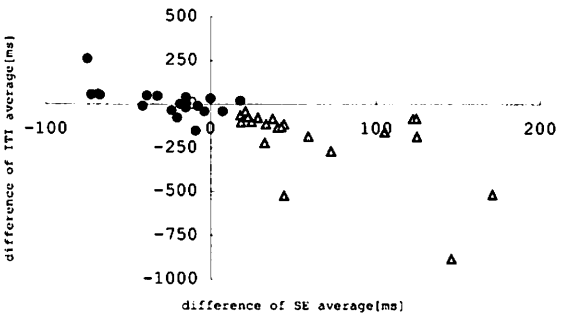
(b)ISI600



(c)ISI900



(d)ISI1200



(e)ISI1800

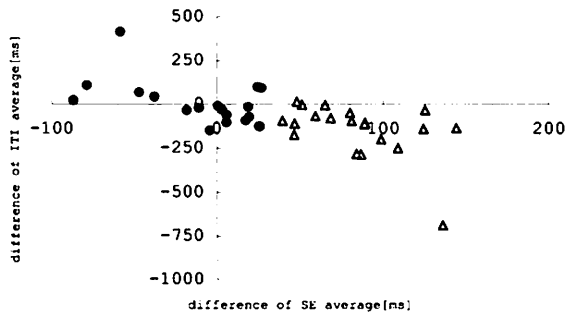


Fig.4 Scatter graph of difference of SE average and difference of ITI average in reading conditions

Table2 Correlation coefficient between difference of SE averages and difference of ITI averages in reading conditions

ISI	Cluster1	Cluster2
450	-.682	-.42
600	-.622	-.626
900	-.634	-.417
1200	-.607	-.552
1800	-.528	-.488

Next, we investigated whether there is the relation between a fluctuation of SE and an ITI in a reading condition. So, Fig.4 and Table2 were drawn up by similar procedures to Fig.3 and Table1. In this condition, each cluster has a high correlation coefficient between a difference of ITI average and a difference of SE average (Fig.4, Table2).

4. Discussion

4.1 Temporal development of ITI

Three type behaviors of a temporal development of ITI were observed on the second 40 taps. One decreases. The other is stable. And the last increases.

It is assumed these behaviors were influenced by a perceived time difference between a subjects' tap and a stimulus, because subjects were instructed to synchronize their taps with stimuli as precisely as possible.

In our experimental condition, auditory stimuli were always presented after subjects' taps on the second 40 taps. Therefore, if subjects perceived an actual order exactly, ITI always increased.

However, in fact, ITI decreased and unchanged trials were observed (Fig.2a,b). These results prove that there is a condition different from actual to perceived order.

According to Fraisse hypothesis, the factor of negative asynchrony is a time difference between signals from different senses. In our experiments, if a presented SE is longer than the time difference between auditory and tactile stimuli, a perceived order is inverted from actual.

In Fig.3 and 4, the case of a horizontal value is lager than 0, and in case of a vertical value is smaller than 0. Therefore, in this condition, Fraisse hypothesis is appropriate to describe a system that causes negative asynchrony.

4.2 ISI dependency of ITI difference.

In cluster2, in condition of ISI >= 900, a correlation coefficient between the difference of ITI average and the difference of SE average was lower than in condition of ISI <= 600. The result implies that there are two systems to cause negative asynchrony. So, it is coincided with former studies.

Additionally, in the case of ISI >=900 on a reading condition, its correlation coefficient has little difference from ISI <=600.

Therefore, in the case of ISI >= 900 on a normal condition, it is suggested that an attention is used.

Komatsu & Miyake suggested that there was a boundary of two dominant dynamics of negative asynchrony on 900 <= ISI <= 1800[8]. It is nearly coincided with our result, and a boundary of each ITI behavior was on 600<= ISI <=900.

In our study, a time range that is longer than 2-3 seconds was not examined. However, in former studies, the range was investigated by various methods [9][10]. It is suggested that human time perception uses an attention and a working memory in the time range.

5.Conclusion

In our study, we examined an SE fixed synchronization tapping to investigate an influence of SE with subject's time perception and to investigate a system of negative asynchrony.

As a result, following things have been revealed.

- There is the condition that a contrary order was perceived.
- A presented ISI in the first of 20 taps provides two ITI behaviors.
- One shows a high correlation coefficient between the difference of ITI average and the difference of SE average. This behavior was observed in condition of ISI <= 600 mainly.
- The other shows a low correlation coefficient. And it was observed in the condition of ISI <= 900 mainly.
- This behavior of was not observed in a reading condition.

Moreover, following suggestive things have been acquired.

- A behavior shows a high correlation coefficient that is explained by Fraisse hypothesis. A system of the behavior shows a linear response of ITI from a fluctuation of SE.
- A system that causes a behavior of a low correlation coefficient used attention. This system shows a nonlinear ITI response from a fluctuation of SE

In this study, we operated this examination out of consideration of an ISI fluctuation. So then, we need analysis their influence.

At present, we practice a synchronization tapping task with brain imaging in cooperation with outside organizations. We hope that our results lead to these results.

References

[1] Stevens L.T, On the time sense, *Mind*, 11, 393-404.(1886)

[2] Gisa Aschersleben, Temporal Control of Movements in Sensorimotor Synchronization, Brain and Cognition, 48,66-79, (2002),

[3] Penelope A. L., R. Christopher Miall, Distinct systems for automatic and cognitively controlled time measurement: evidence from neuroimaging. , Curr. Op. in Neurobiology, 13, pp250-255, (2003)

[4] Dunlap, K.: Reactions on rhythmic stimuli, with attempt to synchronize. , Psychological Review, Vol.17, pp.399-416 (1910)

[5] Miyake Y., Heiss J. & Poppel E.: Dual-anticipation in sensory-motor synchronization, Proc. of 1st Ins. Symp. On Measurement, Analysis and Modeling of Human Function (ISHF2001), Sapporo, Japan, pp.61-66 (2001)

[6] Fraisse P., The sensorimotor synchronization of rhythms, In J. Requein(ed), Anticipation et comportement, Centre National, Paris, pp.233-257, (1966)

[7] Bruno, H. Repp: Processes underlying adaptation to tempo changes in sensorimotor synchronization, Human Movement Science, Vol.20, pp.277-312, (2001)

[8] Komatsu T., Miyake Y., Time-series Analysis of Anticipatory Behavior in Synchronization Tapping Task, Trans.SICE, 39(10), 952-960, (2003)

[9] Brown, S. W., Attentional resources in timing: interference effects in concurrent temporal and nontemporal working memory tasks, *Perception & Psychophysics*, 59(7), 1118-1140.(1997)

[10] Kagerer, A., Cortical involvement in temporal reproduction: evidence for differential roles of the hemispheres, *Neuropsychlogia*, 40, 357-366.(2002)