SICE Annual Conference in Fukui, August 4-6, 2003
Fukui University, Japan

Two types of time perception in synchronization tapping task

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Abstruct
Synchronization tapping task is one of the experimental tasks to research predictive action. In former studies, Inter Stimulus-onset Interval(ISI) was used as control parameter. However the method cannot investigate the perception process of Synchronization Error(SE). In this study, we used SE as control parameter. As a result, two types of time perception were observed. These were shown as continuous and discontinuous SE dependency of predictive action.

Keyword : Synchronization tapping, Time perception, Predictive action,

1.Introduction

In communication, if we only exchange information by turns, our action will be discontinuous. Therefore, it is difficult to realize smooth communication in such way. In contrast, it is known that two persons' gesture autonomously entrains to realize smooth face-to-face communication[1].

People communicate with other people on the media with the development of information technology, e.g. the Net. However, the most of these communications are access to static information as typified by WWW. In such ways, it is difficult to realize smooth communication. In scene of communication study, CSCW, tele presence and remote education are studied[2][3][4][5][6]. These studies focus on multi modality. The purpose of multi modalization is argumentation of reality. However, argumentation of reality by multi modalization have problem to realize smooth communication. For example, in remote communication, information transfer will have delay. In a case of long delay, our information exchange will be alternately. Thus we cannot realize smooth communication.

Thereby, we will realize smooth communication through different approach. Our goal is to make artifacts which support co-emergence[7][8][9][10][11].

In order to construct artifacts that cause predictive action in communication, an analysis of predictive action is necessary. Our group has researched the mechanism that causes predictive action which is called "Negative Asynchrony".

"Negative Asynchrony"[12][13][14] is caused on "Synchronization tapping". Synchronization tapping is a task that subjects synchronize with periodic sensory stimulus by tapping. Negative Asynchrony is a phenomenon that subject's tap precedes sensory stimulus by few 10 ms. The phenomenon shows signal transmission of motor nerve is earlier than stimulus presentation.

In former studies[15][16][17], it is suggested that Negative Asynchrony has two kinds of mechanism. One of mechanisms uses attention, and another one does not. According to Fraisse hypothesis[18], Negative Asynchrony is caused from time difference between tactile signal processing and auditory signal processing. Time difference them influences time difference between tap onset and auditory stimulus onset(SE:Synchronization Error). In former studies, SE was analyzed by using interval of auditory stimuli(Inter Stimulus-onset Interval). From these results, it is suggested that SE influences subjects' perception. However, it cannot be explained how SE influences subjects' perception. Therefore, in this study, we used SE as control parameter. And we analyze interval of subjects' taps(ITI: Inter Tap-onset Interval), because it is influenced by the difference between peceived tap onset and perceived auditory stimulus onset. Finally, we aim to investigate these mechanisms of Negative

PR0001/03/0000-3211 ¥400

Asynchrony and the influence of events perception for these mechanisms.

2.Method

2.1 Parameters and Task

Parameters that are used in synchronization tapping experiment are shown in Fig.1. Measured data are stimulus onset and tap onset. Then ISI (Inter Stimulus-onset Interval)[ms], ITI (Inter Tap-onset Interval)[ms], and SE (Synchronization Error)[ms] are calculated by stimulus onset and tap onset.

Subjects were instructed to synchronize periodic pulse sound onset and tap onset as possible as precisely using right hand index finger. Keeping rhythm by using their body and keeping rhythm by dividing time interval of pulse sounds were restricted. 5 kinds of ISI length (450,600,900,1200,1800) were used. Duration of auditory stimuli is 100ms. Frequency of auditory stimuli is 500Hz. Volume of auditory stimuli is comfortable.

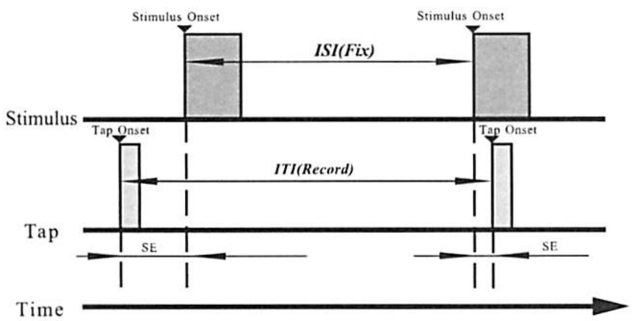
2.2 Subjects and System

5 male right-handed healthy subjects participated in this experiment. Their ages ranged 20's. All subjects were used to synchronization tapping task through other experiments or pilot study.

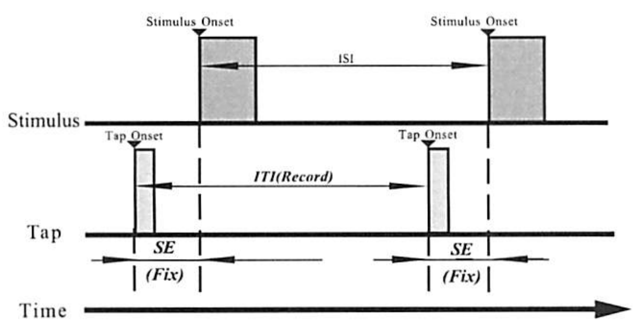
The experimental system was running on single task OS mounted on PC. Auditory stimuli were presented to subjects through the headphone that was connected PC. The button for subjects pushing was connected on parallel port. RTC (Real Time Chip) was used for timekeeping. Time resolution was set 1/2048s.

2.3 Procedure

Subjects were instructed to synchronize auditory stimulus onset and tap onset as possible as precisely. 1 trial consists of 60 taps. 60 taps were divided into 2 parts, first 20 taps as condition 1, later 40 taps as



(a) Experiment setting of first 20 taps



(b) Experiment setting of remain 40 taps

Fig.1 Parameter setting of this experiment

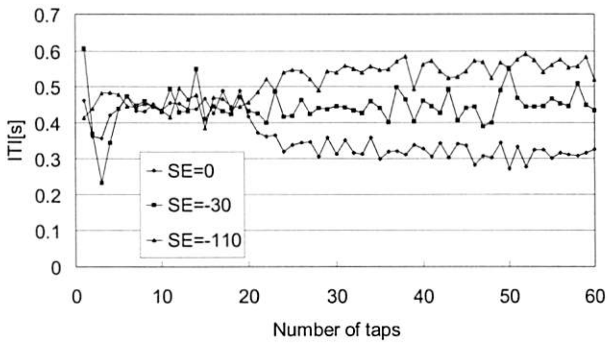
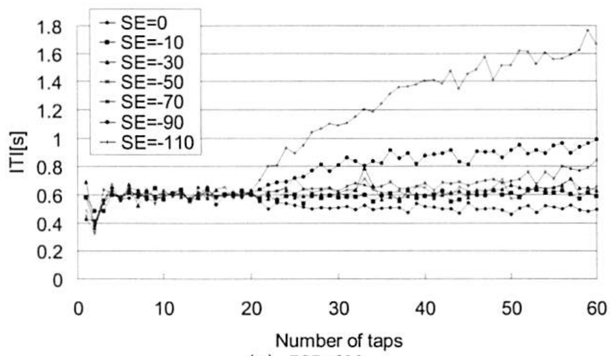
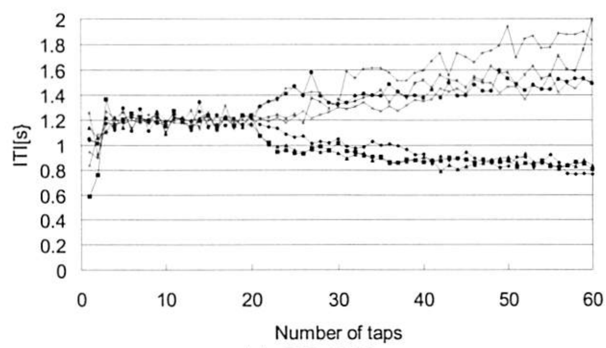


Fig.2Typical temporal deveropment of ITI(ISI=450).

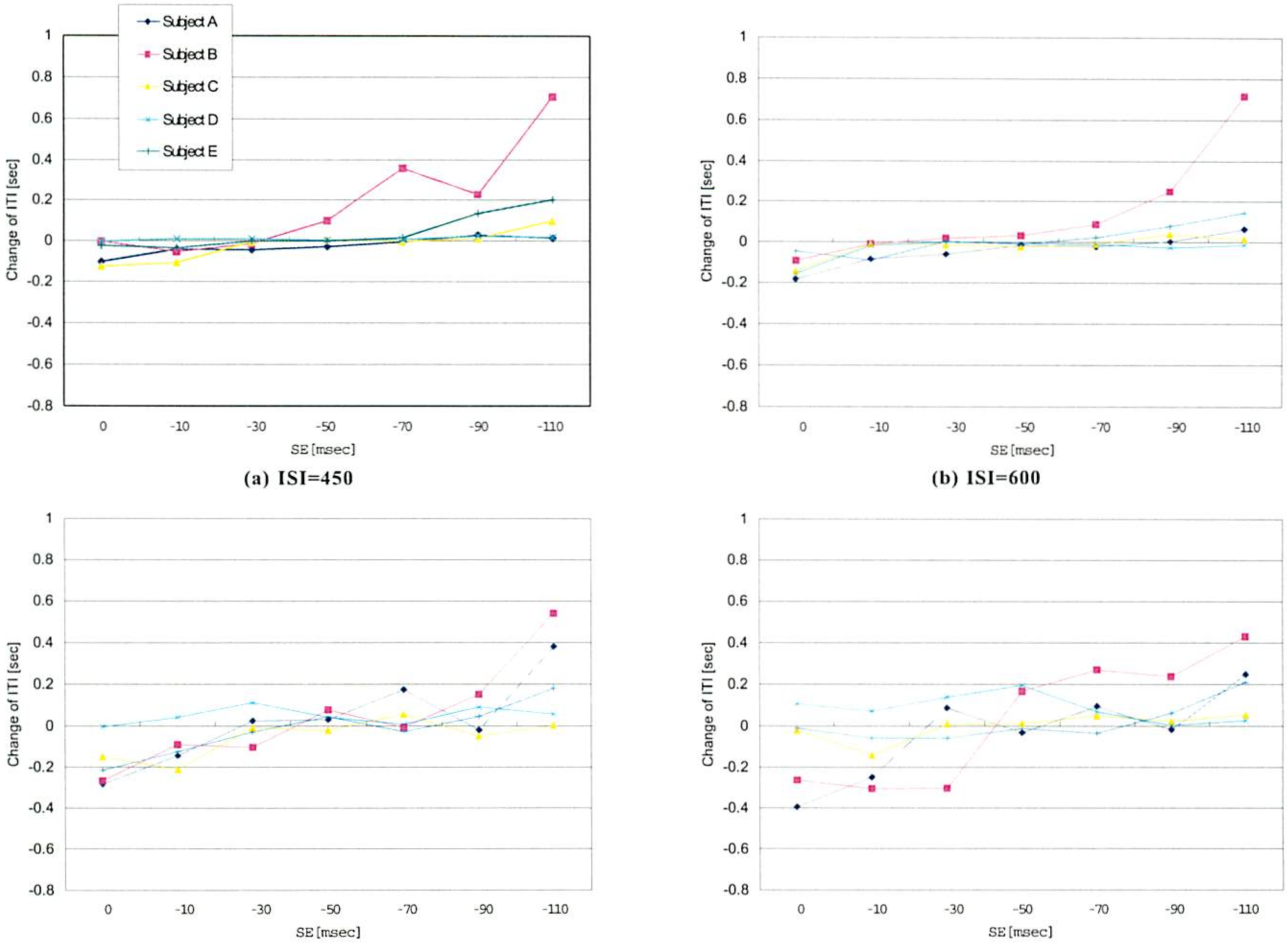


(a) ISI=600

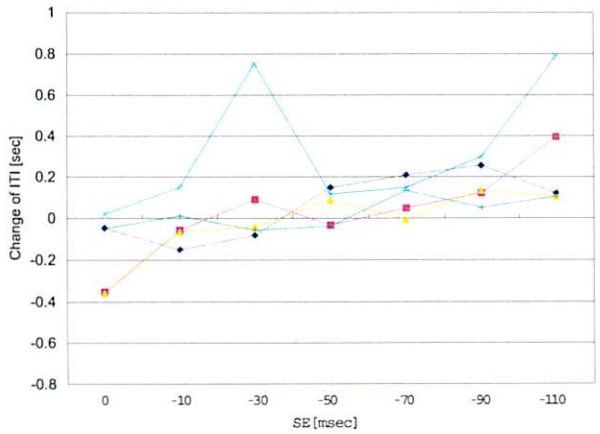


(a) ISI=1200

Fig.3 Temporal deveropment of ITI.



(a) ISI=450
(b) ISI=600
(c) ISI=900
(d) ISI=1200



(e) ISI=1800

Fig.4 Change of ITI between Setting 1 to Setting 2 from all ISI by all subjects

condition 2.

Condition 1 (first 20 taps); ISI Fix (see Fig.1a).

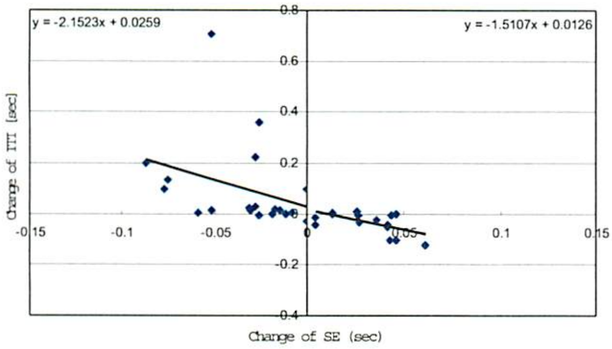
Condition 2 (later 40 taps); SE Fix. Auditory stimuli presented after subjects taps (see Fig.1b).

In Condition 2, 7 kinds of SE (0.-10,-30,-50,-70,-90,-110) and 5 kinds of ISI (450,600,900,1200,1800) were used. The combination of condition 1 and condition 2 was 35. Thus 35 trials were operated each subjects. ITI was used as the target of analysis, because, ITI was influenced by subjects' time perception. 5 taps of the beginning were excluded for analysis, because immediately after biggining of a trial taps have little stability.

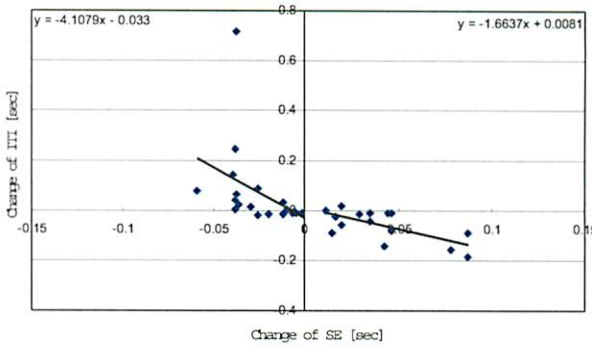
3.Results

3.1 Temporal development of ITI

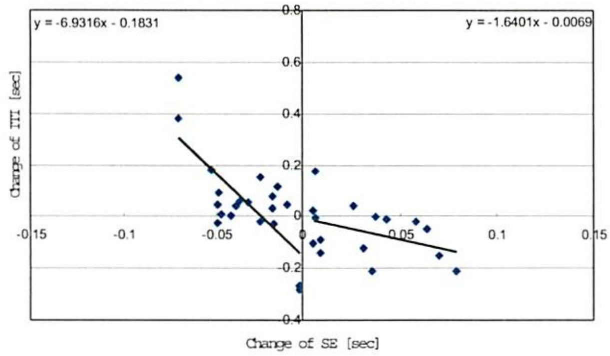
Fig.2 shows 3 examples of temporal development of ITI. In condition 2, ITI shows reduced (see SE=0), stabilized (see SE=-30), and extended (see SE=-110). It is suggested that change of ITI was caused by the subject's time perception, because subjects were instructed to synchronize auditory stimulus onset and tap onset as possible as precisely. Thus, in trials of



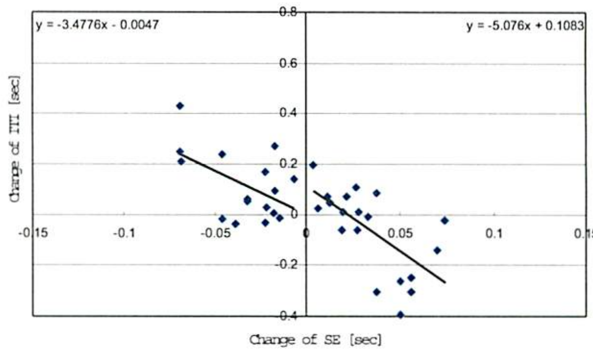
(a) ISI=450



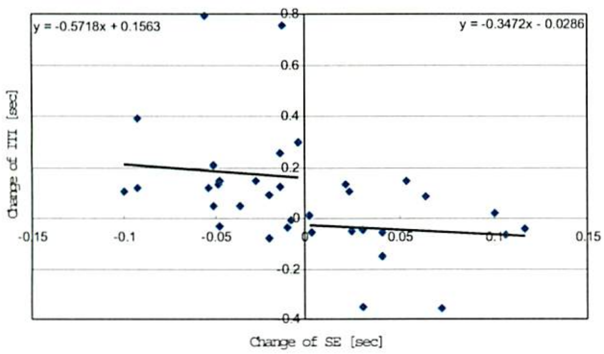
(b) ISI=600



(c) ISI=900



(d) ISI=1200



(e) ISI=1800

Fig.5 Schatter chart of SE change and ITI change.

Table1 Correration of SE and ITI

	SE extend	SE reduce
450	-0.314	-0.575
600	-0.405	-0.678
900	-0.741	-0.407
1200	-0.526	-0.641
1800	-0.071	-0.083

SE reduced, the subject perceived auditory stimulus onset before tap onset. In trials of SE stabilized, the subject perceived auditory stimulus onset stimulus and tap onset simultaneously. And, in trials of SE extended, the subject perceived auditory stimulus onset stimulus after tap onset. However stimulus onset were presented after tap onset. Thus the perceptive sequence of trials of SE reduced and trials of SE stabilized were opposite from actual sequence.

3.2 SE dependency of ITI

Next, we investigate SE dependency of ITI. Then, 2 kinds of SE dependency of ITI were observed(Fig.2). One of dependency is continuous SE dependency of ITI(Fig.3a, ISI=600). In this case, tendency and length of ITI change depend on SE length. Another of dependency is discontinuous SE dependency of ITI(Fig.3b, ISI=1200). In this case, tendency of ITI change only depend on SE length.

Next, we will investigate the difference of SE dependency of ITI through all length of ISI and all subjects. It is shown in Fig.4, the variable of ordinate is the difference between ITI average in condition 1 and ITI average in condition 2, the variable of abscissa is presented SE in condition 2. However, remarkable difference is not observed in each ISI in these figures, because, these figures used SE as abscissa. This parameter shows actual time length of difference between auditory stimuli onset and tap onset.

Therefore, we investigate the difference of ITI change that was influenced by difference between perceived onset of auditory stimuli and perceived onset of tap through all length of ISI, because, subjects' action is influenced by their perception. It is shown in Fig.5, the variable of abscissa is the difference between SE average in condition 1 and SE average in condition 2, the variable of ordinate is the difference between ITI average in condition 1 and ITI average in condition 2. In Fig.5, if SE reduced, this trial is plotted on right side. If ITI reduced, the trial is plotted on below. So was the contrariwise. Approximated lines are shown in each case of SE reduced and SE extended.

In Fig.5a-d (ISI=450-1800), it is shown approximated lines on the downside. In Fig.5e (ISI=1800), gradient of the approximated line is small. Table 1 shows correlation between SE change and ITI change. In table 1, it is shown that the correlation little exist in trials of ISI=1800. However in trials of ISI=1800, the difference between average of ITI change in trial of SE extended and average of ITI change in trial of SE reduced exists. These results suggest that existence of different mechanism which has discontinuous SE dependency of ITI change in trials of ISI=1800.

4. Discussion

The purpose of this study is to investigate two mechanisms of Negative Asynchrony. For this purpose, we use time difference between tap onset and auditory stimulus onset as control parameter. As a result, following things were observed.

1. SE dependency of ITI was observed.
2. In trials of short ISI (ISI=450-1200), continuous SE dependency of ITI change was observed.
3. In trials of long ISI (ISI=1800), discontinuous SE dependency of ITI change was observed.

First, we will consider about SE dependency of ITI. It is likely that SE dependency of ITI can be explained by sequence of tap and auditory stimuli, because subjects instructed to synchronize auditory stimuli and tap. In condition 2, actual sequence of tap and auditory stimuli was fixed, because, auditory stimuli were always presented after tap. In this case, ITI must extend. However, ITI shows 3 kinds of change. These changes include ITI reduced. This opposition can be explained by Fraisse hypothesis. According to Fraisse hypothesis[18], time difference between processing of tactile signal and processing of auditory stimuli exists. If actual time difference between tap onset and auditory stimulus onset is shorter than time difference between processing of tactile signal and processing of auditory stimulus, sequence of tap and auditory stimuli is reversed. In this study, trials of ITI reduced were frequently observed in trials of short SE. It corresponds to the condition that Fraisse hypothesis can explain SE dependency of ITI.

Next, we will consider about continuous SE dependency of ITI in trials of short ISI. In this case, it is likely that time difference between perceived auditory stimulus onset and perceived tap onset was continuously. According to Fraisse hypothesis, time difference between perceived auditory stimulus onset and perceived tap onset was calculated from SE and difference between processing of tactile signal and processing of auditory stimulus. The difference between processing of tactile signal and processing of auditory stimulus cannot change immediately. In short, development of SE change directly influences the difference between perceived auditory stimulus onset and perceived tap onset. Thus, if SE change was continuously, perceived SE change was continuously. (Therefore Fraisse hypothesis apply to explain SE dependency of ITI change and continuous SE dependency of ITI in trial of short ISI.)

Finally, we will consider about discontinuous SE dependency of ITI in trial of long ISI. The discontinuous SE dependency of ITI was observed in trials of ISI=1800. In former studies[13)14)19)20], it is suggested that attention and working memory are used for time perception in long interval(2-3s). In the mechanism that was observed in trial of long ISI, a relation of events more strongly influenced than perceived length of time difference. Therefore in this condition of ISI, it is suggested that the mechanism uses higher function of brain.

In this study, a boundary of two mechanisms exists between ISI=1200-1800. It corresponds to the boundary of switching dominant system that was suggested by Komatsu et al[17].

This study cannot prove mechanism of predictive action in trials of ISI=1800 which uses working memory. However, it can be investigated by dual task method that used in former study[16].

5. Conclusion

In this study, we analyzed interval of subjects' taps to investigate effect of perception of time difference between tap onset and auditory stimuli onset on synchronization tap. Thereby we controlled time difference between tap onset and auditory stimuli onset. As a result, it is suggested that existence of the mechanisms which can be explained by Fraisse hypothesis and cannot. The mechanism that cannot be explained by Fraisse hypothesis uses attention. The mechanism is strongly influenced by relation of events than perceived length of SE. The boundary of these mechanisms is between ISI=900-1800. These results support former researches.

This study is only personal predictive system which can make reference, because the system included only one person. However, we hope to investigate available knowledge for system constructing like face-to-face communication, thorough analysis of co-operative tapping.

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