Estimation of reaction time in continuous judgment

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Abstract

In the continuous judgment, there is a time lag (reaction time) between the presentation of sounds and the participants' responses using fingers' movements to them. Continuous judgment is a kind of tracking task and the efficiency of tracking task can be evaluated from the coefficient of correlation between physical values and participants' responses. The coefficient of correlation between instantaneous judgments and sound levels are different depending on the envelope pattern of sound stream. Factors determining the relation between the time lag and the coefficient of correlation were examined.

1. Introduction

In continuous judgment, subjects are required to judge the instantaneous loudness and respond by pressing an appropriate key on a computer keyboard. There is a time lag between the presentation of sounds and their responses using finger movements. Continuous judgment is a kind of tracking task and the efficiency of tracking task can be evaluated from the coefficient of correlation between physical values and subjects' responses.

As shown in an example in Fig.1, there is a good relationship between them [1]. This means that this tracking task is a good tool to measure the loudness of level-fluctuating sound. Also, as shown in Fig.2, the values of the coefficient of correlation between physical values and subjects' responses showed systematical change according to the time lag. The time lag when the highest correlation can be obtained is presumed as the reaction time.

The reaction time is affected by several factors, such as individual differences, the envelope pattern of the sound stream, cognitive properties of sound sources and so on. For example, when a car is approaching, passing and then leaving, we can easily predict the level pattern of the sound source along time axis. In this case, the reaction time may be short.

The experiment of continuous judgment using the sounds in our daily lives was conducted in Japan [2]. The same experiment was conducted with German participants in Munich [3] using a new software. On the basis of the data with German participants, the factors were examined which affect the time lag and the coefficient of correlation between judgments and sound levels under different temporal conditions.

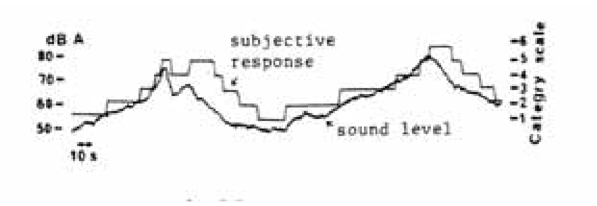

Fig.1 An example of the result [1]

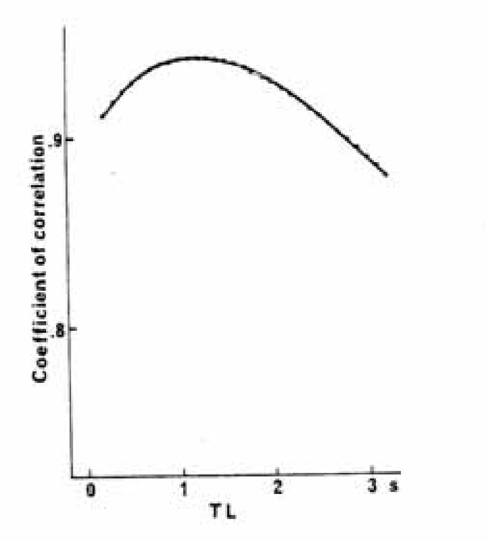

Fig.2 Relation between coefficient of correlation and time lag [2]

2. Experiment

A stimulus of about 7 minutes was used, consisting of twelve sound sources: melody of a mobile phone, footsteps, road traffic noise, sound from a vacuum cleaner, sound of dishes being washed, people talking, aircraft noise, fire engine, dog barking, telephone ringing, train noise and sound from a printer. Steady state background noise of 38 dB was added to these stimuli. The participants were requested to judge the instantaneous loudness of the stimulus by means of a seven-point category scale from "1: very soft" to "7: very loud" and to press the keyboard button corresponding to their impression of loudness. One female and eleven males with normal hearing ability aged between 23 and 55 participated in the experiment. The experiment was conducted in the sound-proof room in Technical University of Munich.

3. Results and discussion

3.1 Relation between temporal pattern and time lag

Taking the reaction time into account, the instantaneous judgments sampled every 100 ms of 12 participants were averaged. When loudness or noisiness is judged, usually a good correlation is found between instantaneous judgments sampled every 100 ms and L_{Aeq}. The new software for the method of continuous judgment by category made it possible to examine easily the reaction time to each portion of the long-term sound and the reaction time to each sound source was estimated. The results are shown in Table 1 and Fig.3. It was found that there are big differences among sound sources in the time lag at which the highest correlation between judgments and L_{Aeq} was obtained. There was a tendency that as longer the reaction time was, the lower the coefficient of correlation. The result suggests that the temporal patterns of the sound stream have strong influence on the response. The following factors may be involved in this result.

3.2 Tracking ability

When the level change of sound is too fast, the fingers' movement can not follow the change. As we suggested in our former presentation, there may be a similar perception of the loudness of temporally varying sounds as to the pitch perception of a musical sound with vibrato. Even if we detect the temporal fluctuation of sound level, the loudness may be determined by a representative value in a certain period.

3.3 Integration time

To find the most appropriate integration time, the sound energy was averaged for various durations and correlated with the instantaneous judgment in our former study [1]. In our former study using road traffic noise, it was found that the instantaneous judgment showed the highest correlation when the preceding sound energy was averaged for 2.5 secs. This value may reflect the psychological present [4]. The similar analysis was conducted using the results of the sound from footsteps with German participants since the sound from footsteps has a quite different temporal pattern of sound level from road traffic noise. The result is shown in Fig.4. The highest correlation was found when the preceding sound energy was averaged for 0.6 sec. The integration time may be different depending on the sound level pattern.

Table 1

sound source	r	RT
all	0.843	1.49
melody	0.508	3.93
footsteps	0.625	2.35
train	0.900	1.26
vacuum cleaner	0.957	1.58
dish	0.431	2.08
voice	0.668	1.93
aircraft	0.939	0.91
fire engine	0.940	0.77
dog	0.369	3.18
telephone ringing	0.386	4.68
road traffic	0.953	0.99
printer	0.686	1.56

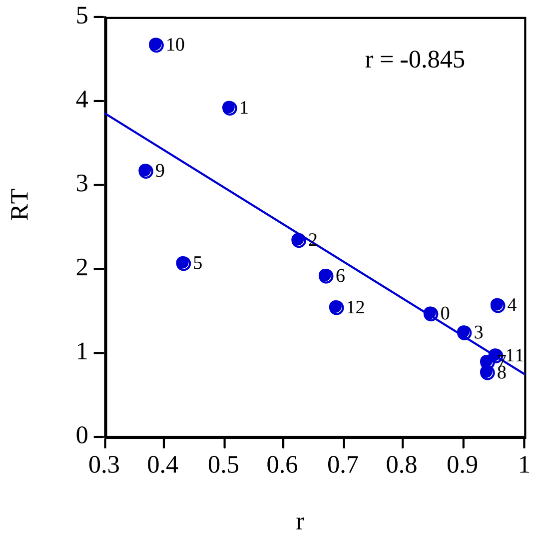

Fig.3

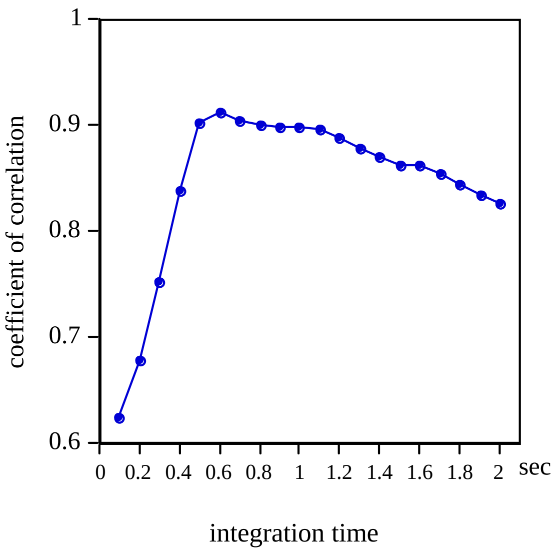

Fig.4 Relation between coefficient of correlation and integration time.

The physical present is a point but the psychological present is not and may have a certain duration during which subjective impressions are integrated and perceived as a unit. If the coefficient of correlation between the integrated physical values and the instantaneous judgments is taken as an index of the psychological present, the integration time which shows the highest correlation with the instantaneous judgment may represent the duration of the psychological present.

4. Final remarks

Sounds give us information by temporal fluctuation. There can be no auditory pattern without temporal stream and little information is conveyed without fluctuation. It is useful to examine instantaneous impressions which correspond to the temporal structure of sounds in order to examine the perception of non-steady state sounds. Continuous judgment is an appropriate method for this purpose. In this method, the tracking ability of fingers' movement to the temporal change of sounds should be made clear. Concerning various temporal patterns of stimuli, the time lag and the coefficient of correlation between subjective response and physical values are investigated. According to the results, these indices are the useful tool to know the loudness of non-steady state sounds and the integration time of sound energy is a kind of measure to guess psychological present.

References

[1] S. Kuwano and S. Namba, "Continuous judgment of level-fluctuating sounds and the relationship between overall loudness and instantaneous loudness", *Psychological Research*, 47, 27-37 (1985).

[2] S. Kuwano, S. Namba and T. Kato, "Memory of the loudness of sounds using sketch method", *Proceedings of Inter-noise 2003*, CD-ROM (2003).

[3] S. Kuwano, H. Fastl, S. Namba and T. Kato, "Memory of the loudness of sounds using sketch method – comparison between German and Japanese results", (2003) (unpublished)

[4] P. Fraisse, *Psychology du Temps*, (Press University, 1957), (Japanese translation by Y. Hara, revised by K. Sato).