Model of "Unconscious" Duration Experience while Listen to Music and Noise

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In daily life, we usually pay no attention to time except for special situations such as going on a trip and attending one's office in the morning, so that such an unconscious sense of time is discussed here. To ensure that subjects provided information on an "unconscious" duration experience without any attention to time, they were not acquainted with the real purpose of this experiment. Subjective preference judgment of the sound field was conduced as a masker investigation in parallel in the duration experiment. After subjective preference judgment for sound field, an experiment (with 102 university students as subjects) concerning an impression of time duration presentations of two different pieces of music was conducted. Of the eighty subjects who judged a slow "quiet" music piece (music A; period: 9.26 s) as more preferable than a fast "active" music piece (music B; period: 6.26 s), 70-% of rated the duration of music A as longer than it's the time ratio (1.48, i.e., the ratio: time of music A to time of music B), $p < 0.01$. According to the model of duration experience, the clock pulses generated by endogenous oscillators and received at receptors in the brain might be more suppressed in the case of the active music than in the case of the quiet music as well as environmental noise around 75 dBA.

Keywords: "unconscious" duration experience, sound stimuli, model of duration experience, endogenous oscillators, a number of pulse integrated, suppression by external stimuli, receptor

1. INTRODUCTION

1.1. Three Stages of Human Life

An approach called "temporal design" in addition to spatial design in the field of architecture and the environment has been proposed (Ando, Johnson and Bosworth, 1996; Ando, 2004, 2009a). In regards to this approach, what can be thought of as three stages of human life (Figure 1), such that;

(1) First stage is body.
(2) Second stage is mind, and
(3) Third stage is personality, which is the source of creation and the most unique to man.

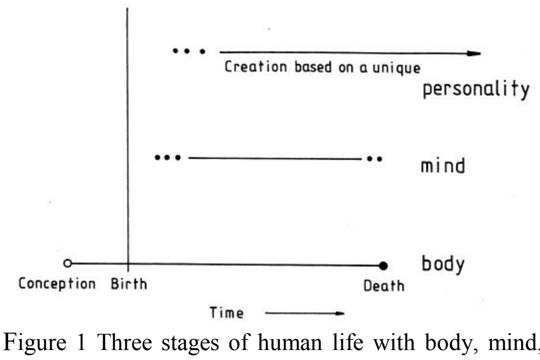

Figure 1 Three stages of human life with body, mind, and personality, which is a base of creation contributing to society even after the first and second lives.

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Animals do have the first and the second stage of life, however, not the third life, because animals have no system integrating knowledge over the lifetime. All useful creations that may contribute to human society and any living things for a long time have been based on the unique and healthy personality of the individual. It is highly recommended, therefore, that human environment be designed for these three stages of life, which is deeply related to each individual and encouraging each personality. A well-designed environment would be a meeting place for art and science, and, in turn, may help to discover the individual personality as the minimum unit of society.

In the very early stage of human life such as babies and children, for example, environment containing temporal and spatial information close to them is designed, because of their limited action radius. The temporal information containing in the environment as well as the maternal talk to her child play important roles for development of the left cerebral hemisphere. The spatial information-containing environment such as art works and space forms including sculpture can help for development of the right. The theory of designing physical environments that takes account of temporal factors together with spatial factors is based on the specialization of cerebral hemispheres (Ando, Johnson and Bosworth, 1996, Ando, 2003, 2009a). For the temporal design, above-mentioned three-dimensional lives are taken into consideration, which is analogous to the Shakespeare Theater having three stages; frontal stage, rear stage and upper stage. As for life of the body, for example, the effects of aircraft noise on the developments of the body of unborn babies have been reported (Ando and Hattori, 1977a). As for life of the mind and life of individual personality, the effects of noise on the development of the cerebral hemispheres of children were demonstrated (Ando and Hattori, 1977b; Ando, 2001). These effects of daily noise are accumulated over a year and remain over several generations.

1.2. Model of Duration Experience

The present study is concerned with duration experience regarding time of mind. We previously investigated unconscious duration experience of university students covering three-year periods of their school lives from when they were 3 to 18 years old (Ando et al, 1999). Results showed that in regards to duration experience for elementary school periods (below 12 years old) students reported time passed slowly (the mean value was about 1.2 times), in reference to that for the three years (13-15 years of age) of their junior high school ($p < 0.01$). In addition, study shows that students for senior high school periods (16-18 years old) felt the time was shorter (the mean value was about 0.8 times), than that of their junior high school periods ($p < 0.01$). These results imply that time seems to pass faster as the age of students increases.

To understand such an "unconscious" duration experience conducted without notifying the purpose of investigation to subjects as well as a "conscious" duration experience with notifying the purpose, a model of duration experience is proposed here as shown in Figure 2. Endogenous clock oscillators with characteristic periods can be synchronized with, for example, brain waves, pulsation, and breathing rate inside the body in addition to daily, monthly, and annual cyclical changes in the external environment (Luce, 1971). That is to say morning light may reset a circadian oscillator, and a long-term temperature change may reset a seasonal oscillator. We assume that clock signals from oscillators propagate through a system (media) to a receptor in the brain. Activities of the receptor in the brain depend on a person being awake or being sleep. In the awake state, there are two levels, i.e., "conscious" or "unconscious". In the conscious stage, a person always notices time passing; in the unconscious state they do not notice time passing. When a person is in a deep sleep, for example, their receptor gets less endogenous clock signals and they may feel time passes faster unconsciously than it does while they are awake.

Much has been conducted for conscious duration experience for a long time; for example, asking subjects counting for 60 at the speed they thought were about one per second (Luce, 1971). A question arises whether or not music and environmental noise influence an unconscious duration experience. There has only been one study on the effects of sound on an unconscious duration experience (Ando, 1977). Most of subjects showed that time can be accelerated by noise around the level of 75 dBA, feeling that time passes faster than in silence. When the level increased to 90 dBA, then many subjects had an increase in the duration experience. The experiments on unconscious impressions of duration during jet-plane noise presentations to junior-high-school pupils (13- to 14 years of age) from quiet and noisy residential areas are reviewed here in detail.

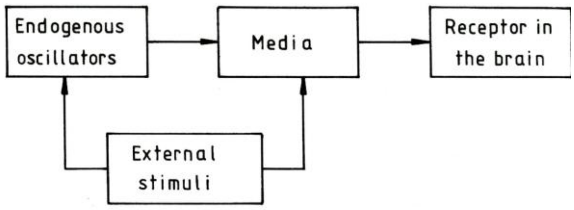

Figure 2 A model of duration experience consisting of endogenous oscillators, media, and a receptor in the brain. According to the model of an auditory-brain system and specialization of cerebral hemispheres (Ando, 1985, 1998), it is acceptable that the receptor exists in the left hemisphere (Polzella, et al. 1977). External stimuli may act as a suppressor of a number of clock pulses from the oscillators, so that the receptor may get less clock pulses and person may feel a short duration (Luce 1971, Ando, 1977). In creating works or the third stage of life receptor gets fewer number of pulses due to deep concentration.

To ensure that subjects provided information on the unconscious duration experience in regard to noise, a masker investigation (in which their urine was collected) to determine effects of noise on internal secretion was performed in parallel. In the first hour of the experiment, picture slides of a world tour were shown in a classroom to make the subjects relax. During the following hour, cycles composed of 60 s of jet-plane noise followed by 60 s of silence were repeated 30 times. As listed in Table 1, the peak sound pressure levels (SPL) in all the classrooms of the junior high school in the study were 75 $\pm$ 2 dBA (group A: 20 subjects; group B: 28 subjects) and 90 $\pm$ 2 dBA (group C: 20 subjects; group D: 25 subjects). Group A and group C subjects lived in a noisy residential area, and group B and group D subjects lived in a quiet residential area. During the hour of noise-silence cycles, the subjects were permitted to look at picture books. For the last hour, the slide show was presented again to make the students relax again. Afterwards, the subjects were given a questionnaire asking for the ratio of the subjective duration of the period of noise to that of period silence. That is, they were asked "How much longer was the noise period than silence period?" The question was carefully explained so that all subjects understood the question and could answer it meaningfully, choosing a ratio from 0.1, 0.2, 0.3, … 5.0. Note that the objective ratio of time is unity, i.e., 60/60 s.

Table 1 Percentage of subjects who rated the duration of noise and silence

Group	Residential Area	SPL at the peak (dBA)	Number of subjects	Percent (%)	R_{50}	Null hypothesis (%)	p
A	Noisy area	75±2	20	80	0.4	50 (R_{50} = 1.0)	<0.05
B	Quiet area	75±2	28	78	0.5	50 (R_{50} = 1.0)	<0.05
C	Noisy area	90±2	20	80	0.7	50 (R_{50} = 1.0)	<0.05
D	Quiet area	90±2	25	52	0.9	50 (R_{50} = 1.0)	---

A notable result is that about 79 % of group A and group B (75 ± 2 dBA) rated the subjective duration of the noise period shorter than that of the silent period ($p < 0.01$; the null hypothesis: 50 %). The rated value at 50 % of subjects (R_{50}) of group A and group B, respectively, are 0.4 and 0.5 ($p < 0.05$). About 80 % of subjects of group C (90 ± 2 dBA) (from a noisy residential area) rated the subjective duration of the noise period shorter than the silent period ($p < 0.05$). However, only about 52 % of subjects of group D (from a quiet residential area) rated it shorter than the silent period.

Accordingly, building on the results of above-mentioned study, in the present study the authors tackle the question whether or not music influences an unconscious duration experience.

2. EXPERIMENT WITH TWO MUSIC STIMULI: "ACTIVE" AND "QUIET" MUSIC PIECES

2.1. Procedure

The number of subjects that participated in this experiment was 102 (20 - 22 years old), all of whom were university students attending a class on environmental psychology and physiology. To provide a condition of an unconscious duration experience listening to music, subjects were not acquainted with the real purpose of the study. As a masker, we demonstrated something subjective preference for the sound field without and with echo, which consisted of the direct sound and a single reflection with delay time, Δt_1 = 0 ms or 128 ms, was performed (Ando, 1985, 1998, 2007). Subjective preference is regarded as a primitive response entailing judgments that steer an organism in the direction of maintaining life to enhance its prospects for survival (Ando, 1998, 2007). Thus, subjective preference is related to aesthetic issue. The scale values of subjective preference of the sound field (Ando, 1983, 1985) and the visual field (Ando, 2009b) have been described by both temporal and spatial factors extracted from correlation functions. The music sources applied here were music A (a slow tempo quiet music piece: Royal Pavane by Gibbons, duration of piece: 9.26 s with a peak level of 70.5 ± 2 dBA; the effective duration of autocorrelation function τ_e = 127 ms) and music B (a fast tempo active music piece: Sinfonietta, Opus 48 by Arnold, duration: 6.26 s with a peak level of 84 ± 4 dBA; τ_e = 43 ms). The values of τ_e represent a similar repetitive feature of music signals and are related to the preferred delay time of the reflection and reverberation time (Ando, 1985, 1998). Values of running ACF τ_e as a function of time for these music have been published previously (Ando, Okano and Takezoe, 1989, see also FIGURE 3.5, Ando, 1998). Though the values of τ_1 corresponding to pitch, i.e., $1/\tau_1$ (Inoue, Ando and Taguti, 2001; Ando, 2008) were not measured, the value τ_e of music A, which is related to τ_1, were greater than those of music B. This implies that pitch of music A and/or frequency component is lower than those of music B. The time durations (Music A: 9.26 s and Music B: 6.26 s) were selected for ease in judging preference or echo disturbance effects, so that its ratio was 1.48 = 9.26 s/6.26 s. Usually, subjects perceived echo in presence of music B for the single reflection with 128 ms delay time, but did not in presence of music A rather the preferred condition (Ando, 1985). The two music pieces were reproduced four times in the room by a two-channel loudspeaker system, one for the direct sound and another for the single reflection, placed in front of the lecture room. The order of music presentation was: A (Δt_1 = 0 ms), A (Δt_1 = 0 ms), A (Δt_1 = 128 ms), A (Δt_1 = 128 ms); B (Δt_1 = 0 ms), B (Δt_1 = 0 ms), B (Δt_1 = 128 ms), B (Δt_1 = 128 ms). Though the peak levels were different, the perceived loudness was almost the same as the other adjusted by one of the author. After presentation, a questionnaire was given to each subject. The first question was "Do you prefer music A or music B." The second question was "How much longer was the duration of music A (Gibbons, quiet music) than music B (Arnold, active music), choosing a "ratio of A to B" from 0.1, 0.2, 0.3, … 10.0 times. These values were selected by possible minimum and maximum ratios. The time needed for the SPL measurement at four different positions, demonstration of subjective preference and experiment of duration experience was about 40 minutes. After then, usual lecture on environmental psychology including subjective preference theory was given for about 50 minutes.

2.2. Results

The percentage cumulative frequencies of two groups, namely subjects who preferred music A (group A) and music B (group B), are plotted as a function of the time ratio in Figure 3 (also see Table 2). About 70% of group A rated the ratio of subjective duration as greater than the physical ratio (1.48); that is, the subjective duration of music A was thought to be longer than that of music B ($p < 0.01$). The difference between duration experiences of group A and group B may be found in values expressed as R_{50} = 2.0 and

R_{50} = 1.5 times, respectively, where (R_{50}) is the rated value at 50 % of subjects. This slight difference, however, was not achieved as significant.

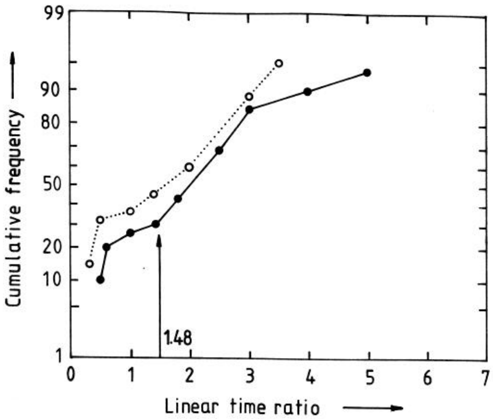

Figure 3 Percentage cumulative frequencies of two groups of subjects classified by their preference as a function of the ratio of the duration experiences for the music A period and that for the music B period.
●: Music A: 80 subjects, who judged music A as preferable to music B.
○: Music B: 22 subjects, who judged music B as preferable to music A.

3. DISCUSSION

First, According to the model shown in Figure 2, the noise environment around 75 dBA might suppress signals from endogenous clock oscillators such as of specific brain waves with characteristic periods. When the sound pressure level increased to about 90 dBA as indicated in Table 1, the rate was decreased to 52 % of subjects from a quirt residential area due to such annoyed noise. It is considered that the intensive noise gets their attention; consequently, the conscious duration experience was longer. However, this fact was not true for subjects from a noisy residential area; that is the rate did not changed from about 80 %. This result is considered to be the chronic effect of daily noise. This may relate to people living in a noisy area near an airport, who felt busy even though they were doing no particular jobs. They might "lose" the time in the second stage of life (mind) during the noise period; for example, unconscious duration experience of subjects in R_{50} of Group A was only 0.4 times shorter for the noise period in relation to the quiet period.

Of particular interest is the difference in subjective preference for the two music pieces. More subjects in-group A rated the ratio of subjective duration as greater than the physical ratio (1.48) as listed in Table 2. The subjective duration of music A with lower pitches was longer significantly than that of music B ($p < 0.01$). It is considered in the media that the pulse number is relatively suppressed in listening such active music B more than quiet music A. It is remarkable that a conscious duration sensation is longer at a lower pitch of the complex tone (500 Hz) than that at a higher pitch (3000 Hz) (Ando, Saifuddin and Sato, 2002; Saifuddin, Matsushima and Ando, 2002), The pitch is determined by the value of τ_1 extracted from the ACF of the source signals (Inoue, Ando and Taguti, 2001). According to the model of auditory and brain systems (Ando, 1985, 1998), the value of τ_1 is associated with the left hemisphere. When temporal factors of the sound field are changed, the value of τ_e extracted from ACF of the alpha wave in the left hemisphere is changed significantly, and the most preferred condition, the value of τ_e is the maximum (Soeta, et al, 2002, Ando, 2003). These accept the fact that duration experience is associated with the left cerebral hemisphere (Thomas and Weaver, 1975, Polzella et al, 1977).

Getting into ecstasies over studies or external stresses or both might cause young people unconsciously feel that time is passing faster with increasing age (Ando et al, 1999). In childhood below 12 years of age, they might feel more boredom than when busy with studies or work after 15 years of age; consequently the unconscious duration experience was longer. Pupils younger than 10 years of age, who had experienced a transfer between different elementary schools, felt losing friends and their former environment prolonged their duration experience. For example, Angrilli et al. (1997) and Yang et al. (2007) mentioned "boredom" resulted that subjects' felt longer time passed or time passed slower.

In regard to artistic and scientific creations, a receptor is a typical unconscious level that might come from "out of time" or beyond any specified time (Lauterborn, 2003; Ando, 2009b). Therefore, such a creation based on individual personality might relate to that individual's "third stage of time" (Ando, 2004).

Table 3 summarized both conscious and unconscious duration experiences investigated. In our daily life, it is likely that conscious and unconscious duration experiences depend on human development, sound environment and the three stages of human activities including boredom and concentration on in creative works.

Table 2 Percentages of subjects (university students) who rated the duration of music A and music B.

Group classified by preference	SPL at the Peak (dBA)	Number (valid) of subjects	Percent (%)	R_{50}	Null hypothesis (%)	p
Music A	70.5 ± 2.0	80	70	2.0	50 (R_{50} = 1.48)	< 0.01
Music B	84.0 ± 4.0	22	50	1.5	50 (R_{50} = 1.48)	---

Table 3 Summary of duration experiences, which can be explained based on the model (Figure 2).

Human activities	Number of pulse integrated at the receptor: Smaller number, subjects felt "time passed faster or shorter"	Number of pulse integrated at the receptor: Larger number, subjects felt "time passed slower or longer"
1) In the media, pulse number is suppressed by external stimuli, such that:		
Music with higher pitches (music B)	Unconscious (present study)	
Higher pitch of sound (3000 Hz)	Conscious (Saifuddin et al., 2002)	
Noise (about 75 dBA)	Unconscious (Ando, 1977)	
Noise (about 90 dBA)		Conscious (Ando, 1977) (Quiet living area)
2) Activities of receptor are:		
Higher in children younger than 12 years old		Unconscious (Ando, et al, 1999)
Higher in boredom		Conscious (ex, Yang, 2007)
Lower by aging by working in busy (above 12 years old)	Unconscious (Ando et al., 1999)	
Lowest in creative works	Unconscious (Lauterborn, 2003; see Ando, 2009b).	

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