

Perception of auditory-visual simultaneity changes by ambient illumination

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ABSTRACT

In this study, we investigated changes in the point of subjective simultaneity (PSS) between auditory and visual stimuli by changes in ambient illumination. The test stimuli were a pure tone sound of 1000 Hz at 80 dB SPL and white light of LED at 21.9 cd/m². The illuminance levels at around the light source and at the subject's eyes were adjusted at the following 4 conditions; (100 lx, 100 lx), (100 lx, 1000 lx), (1000 lx, 100 lx), and (1000 lx, 1000 lx). Nine people in their early 20's participated in the experiments. Synchronized sound-light stimuli, which were the same as the test stimuli, were presented as the preceding stimuli, followed by the test stimuli at an interval 1000 ms. The test stimuli had a stimulus onset asynchrony (SOA) of 0, ±20, ±40, ±80, or ±160 ms. After each presentation of the test stimuli, we asked subjects to answer which of the stimuli — sound or light — they perceived first. Then we evaluated the PSS of the test stimuli and considered the influence of ambient illuminance on the PSS. As a result, the PSS shifted toward positive direction. We showed that the PSS shift depended by changes in ambient illumination.

Keywords: PSS (point of subjective simultaneity), ambient illuminance, SOA (stimulus onset asynchrony)

1. INTRODUCTION

There are many researches have been conducted on the simultaneity between auditory and visual information (1, 10). We also have been studying the simultaneity of a paired auditory and visual stimulus (11, 16), and we showed that the point of subjective simultaneity (PSS) between an auditory and visual stimulus shifted depending on the illuminance level at the subject's eyes in the previous paper (16).

The present paper investigates changes in the PSS between an auditory and visual stimulus depending on the ambient illuminance, where the illuminance level changes not only at the subject's eyes but also at around the light source.

2. Experiment

We investigated the perception of simultaneity between an auditory and visual stimulus when ambient illumination changed.

2.1 Stimuli

We used a pure tone of 1000 Hz at 80 dB SPL (sound pressure level) and a while LED light with a luminance of 21.9 cd/m². Both stimuli had a duration of 10 ms. The auditory stimulus had a liner fade-in and fade-out of 2.5 ms to reduce transient responses.

2.2 Apparatus

We carried out the experiments in a soundproof room (D-30; Fig. 1). We generated sound and light stimuli using a stimulus generator (S-15137, Takei Scientific Instruments) controlled by a computer.

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The sound stimuli with amplification through an amplifier (CR-D2, Onkyo) were presented to the subject via headphones (SRH840, Shure), and the light stimuli were presented with a LED (LP-10HW3B). The illuminance levels around the light source and at the subject's eyes were adjusted at the following 4 patterns; (100 lx, 100 lx), (100 lx, 1000 lx), (1000 lx, 100 lx), and (1000 lx, 1000 lx) using spotlights with dimmers located above the subject's head and the light source as shown in Fig. 2. The subject sat on a chair 2 m in front of the light source. The testing space was closed off with a blackout curtain to eliminate all other light.

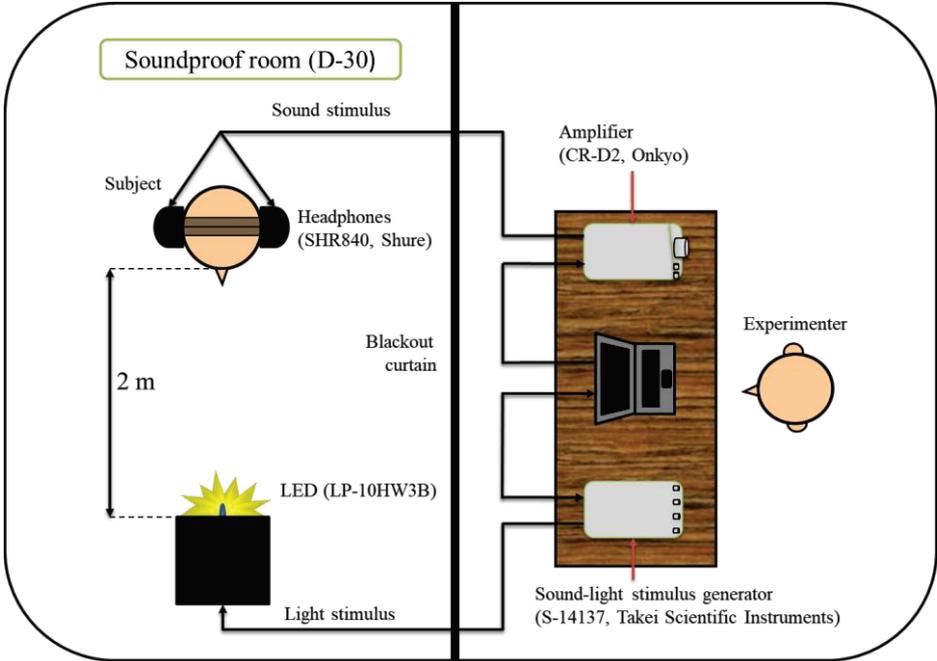


Figure 1 – Experimental apparatus. The sound stimuli were presented via headphone to the subject. The light stimuli were presented with a LED.

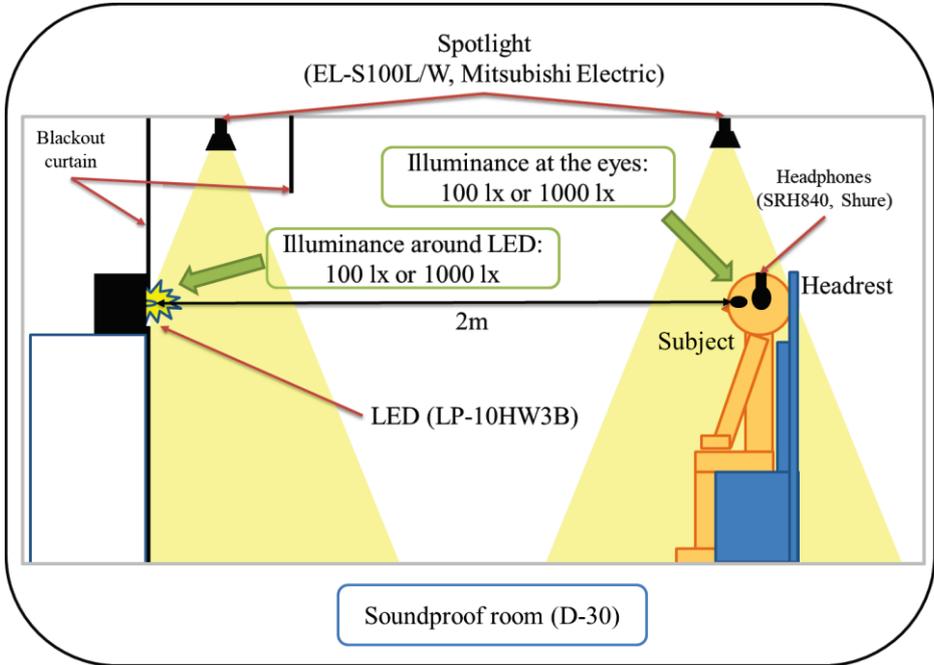
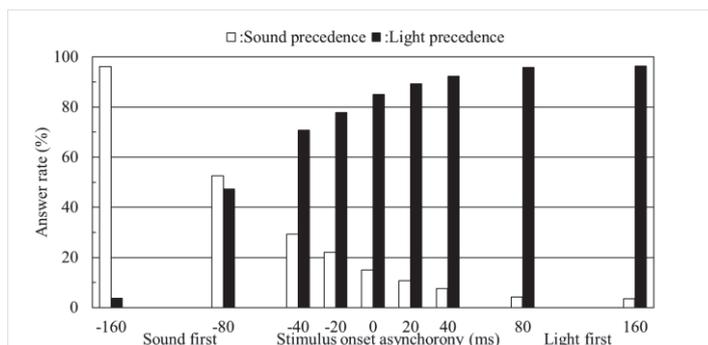
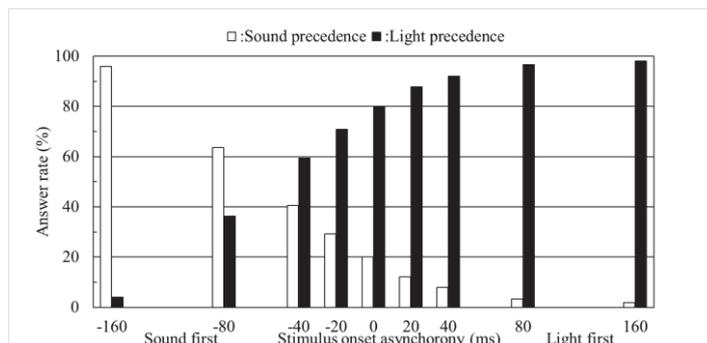


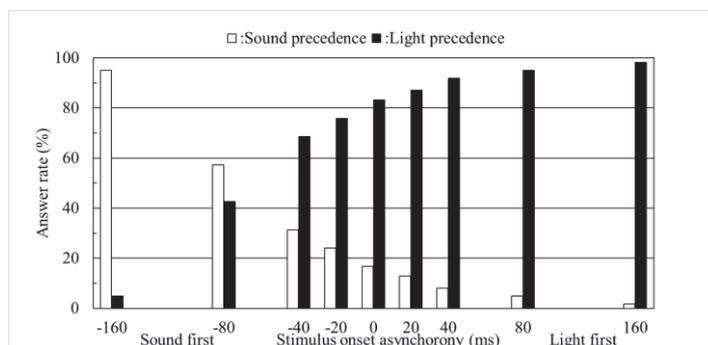
Figure 2 – Schematic figure of the experiment. Illuminance levels at around the LED and at the subject's eyes were adjusted using spotlights with dimmers located above the subject's head and the light source.



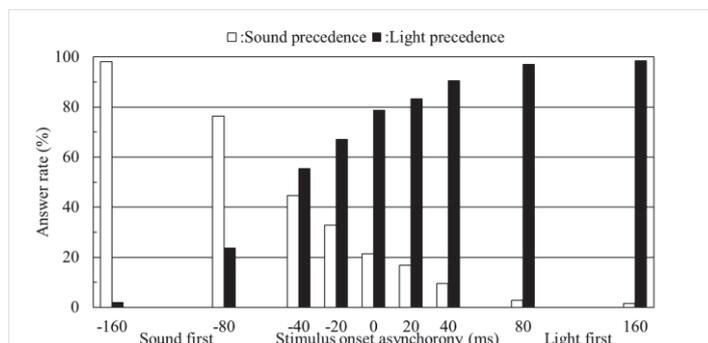
(a) Illumination condition I (around light: 100 lx, subject's eyes: 100 lx)



(b) Illumination condition II (around light: 100 lx, subject's eyes: 1000 lx)



(c) Illumination condition III (around light: 1000 lx, subject's eyes: 100 lx)



(d) Illumination condition IV (around light: 1000 lx, subject's eyes: 1000 lx)

Figure 4 – Experimental results in the conditions I to IV. The vertical and horizontal axes denote the answer rate and the stimulus onset asynchrony (SOA) between the sound and light, respectively. The white and dark bars indicate the perception of sound and light precedence, respectively.

4. Discussion

In order to quantitatively analyze the experimental results, we fitted a psychometric function (11) to the result of each subject in each condition, and obtained the PSS as the 50 % point of the answer rate with respect to the SOA.

Table 2 shows the average values of PSS of all subjects in each condition.

Table 2 – Averaged PSS values in each illumination condition.

Illumination condition	I	II	III	IV
Around light source (lx)	100	100	1000	1000
Subject's eyes (lx)	100	1000	100	1000
PSS (ms)	-71.40	-55.45	-66.70	-43.60

In table 2, all the PSS values were negative, i.e., the PSS shifted toward the perception of sound precedence. In comparing the PSS values between the conditions I and II, where the illuminance level at around the light source was 100 lx, the PSS shifted toward positive direction by 15.95 ms, i.e., the degree of the perception of light precedence increased as the illuminance level at the subject's eyes increased from 100 lx to 1000 lx. This tendency agreed with our previous reports (14, 16), that is, by raising illuminance level at the eyes, relative attention to the LED light decreased, and thus attention to the sound relatively increased. Paying attention to the sound increased the speed of transmission of auditory information, so the sound and light and light were perceived as simultaneous when the light was presented earlier. The PSS then shifted toward the perception of light precedence. The same tendency was shown in comparing the PSS values between the conditions III and IV.

On the other hand, in comparing the PSS values between the conditions I and III, where the illuminance level at the subject's eyes was 100 lx, the PSS shifted toward positive direction by 4.70 ms, i.e., the degree of the perception of light precedence increased as the illuminance level at around the LED increased from 100 lx to 1000 lx. We here evaluated the Michelson luminance-contrast of the LED lights, then the contrast of the LED light decreased as the illuminance level at around the light source increased from 100 lx to 1000 lx as shown in Table 3. We considered that by decreasing the contrast of the LED light, the visibility of the LED light decreased. The deterioration of the visibility of the LED light caused a decrease of relative attention to the LED, i.e., attention to the sound relatively increased. Then the PSS shifted toward the perception of the light precedence. The same tendency was shown in comparing the PSS values between the conditions II and IV.

From the above, we found that the PSS changed not only by changing in the illumination at the subject's eyes, but also by changing in the contrast of the light source.

Table 3 – Michelson luminance-contrast of the LED light.

Illuminance at around the light source (lx)	Luminance of the LED Light (cd/m ²)	Luminance of the peripheral area (cd/m ²)	Michelson of luminance-contrast
100	21.9	0.33	0.97
1000	25.0	4.22	0.71

5. CONCLUSIONS

The point of subjective simultaneity (PSS) between the auditory and visual stimuli shifted toward the perception of light precedence as the ambient illumination increased. The PSS shift depended not only by changes in the illumination at the subject's eyes, but also by changes in the contrast of the light source.

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