PHYSIOLOGICAL RESPONSE BY CONSTRUCTION NOISE ACCORDING TO TEMPORAL CHARACTERISTICS

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Many people who live in the city are exposed to environmental noises such as transportation, aircraft, and construction noises. Especially a construction noise is the most hazard noise source because it generally presents high sound pressure levels and is difficult to reduce in a downtown area. In this regard, individuals experience different levels of stress when exposed to the same sound pressure level because of different noise sensitivity among individuals. Because a sound pressure level that only presents physical information of noises does not consider various individual noise sensitivity, a more effective means to understand individual responses toward noises is required. In this regard, this study investigated individual physiological responses, such as electroencephalogram, electrodermal activity, heart rate, and blood volume pulse, toward construction noises to better understand the impact of construction noises on urban populations. By presenting different individual physiological responses toward impulsive and tonal construction noises, the results of this study showed a potential of physiological monitoring in understanding different individuals’ responses toward noise stressors.

Keywords: Construction noise, Physiological responses

1. Introduction

The construction noise is one of the main reasons of environmental claims in the city [1]. The construction noise significantly affects urban population’s stress because this noise is difficult to manage particularly when the construction site is located in a downtown area. A noise from construction machineries including stationary and mobile ones is the major contributor of construction noise [2]. Specifically, many stationary construction machineries such as a pile driver and a breaker makes high impulsive noises that can cause tinnitus, hearing loss, and a high level of stress [3]. Many studies have been conducted to analyze the impacts of impulsive noises, however, it is difficult to study individual responses toward such noises because individual noise sensitivity varies with different individuals. Taking into account that construction noises are managed based on sound pressure levels without sufficient considerations on individual noise sensitivity, a more effective means to understand individual responses is required.

In this regard, an individual physiological response is useful information to assess the effects of construction noises on urban populations. In these days, several studies tried to apply electroencephalogram
(EEG) device in the construction site to understand workers’ mental status such as emotions and cognitive loads [4,5,6]. In addition, other peripheral physiological responses such as electrodermal activity (EDA), heart rate (HR), and blood volume pulse (BVP) were collected using a wearable device in the field and used to understand worker's physical and mental status toward many stressors in construction site (e.g., workload, working conditions) [7,8], which can be applied in understanding human responses toward noise stressors. As such, this study collects and analyse individual physiological responses according to construction noise types using wearable devices equipped with physiological sensors.

2. Experiment set up

The construction noise sources were collected during the foundation construction stage where many noisy construction equipment is used. During this stage, the impulsive construction noise was recorded from pile driver while the tonal construction noise was recorded from an earth auger as shown in Fig. 1.

![Impulsive construction noise (Pile driver)](image1)
![Tonal construction noise (Earth auger)](image2)

Figure 1: Construction noise equipment.

Each recorded construction noises was presented to one subject using a loudspeaker in the auditory experimental room for two minutes. The overall sound pressure level of recorded construction noises was adjusted to 40dBA while the background noise level of the auditory experimental room was around 20dB. The temporal characteristic of the acoustic stimuli is shown in Fig. 2. The authors also analyze physical and psychoacoustical parameters of presented construction noises as shown in Table 1.

![Temporal characteristic of construction noise](image3)

Figure 2: Temporal characteristic of construction noise.
Table 1: Physical and psychoacoustic parameters of presented construction noises

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Impulsive noises (Pile driver)</th>
<th>Tonal noises (Earth auger)</th>
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<td></td>
<td>$L_{90}$</td>
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<td>38.90</td>
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<tr>
<td></td>
<td>Roughness</td>
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</table>

3. Physiological responses by construction noises

The individual physiological responses toward construction noises were also analyzed by collection physiological signals from an experiment subject. The collected physiological responses are EEG, EDA, BVP, and HR. The EEG responses with impulsive and tonal construction noises were collected using a wearable EEG device (Emotiv Epoc+) [6] and the EDA, BVP, and HR were collected using a wristband-type physiological monitoring sensor (Empatica E4) [8]. Independent component analysis (ICA) was applied to EEG signals to correct signal artifacts and then EEG signals were analyzed [6]. The component activations and 2D component maps of EEG responses are plotted in Fig. 3 and Fig. 4 while the EDA, BVP, HR responses are plotted in Fig. 5. The results showed the clear differences between individual physiological responses toward two different noise types. Specifically, it is inferred from a BVP and HR data that impulsive noises can more highly impact on autonomic nervous system activities by increasing HR and BVP, which is likely to be associated with higher levels of individual stress.

![Component activation of EEG responses](image1.png)

(a) Impulsive

![Component activation of EEG responses](image2.png)

(b) Tonal

Figure 3: The component activation of EEG responses according to construction noises.
Figure 4: 2D component maps of EEG responses according to construction noises.

Figure 5: Physiological responses according to construction noises.
4. Conclusions

The individual physiological responses toward impulsive and tonal construction noises are compared in this study. It was shown that EEG, EDA, BVP, HR responses are significantly changed according to construction noise types. This result showed a potential of physiological monitoring in understanding different individuals’ various responses toward noise stressors. In the future study, the analysis needs to be based on physiological responses from more subjects. Also, applying post-processing such as removing signal noises extracting signal features related to individual responses will help better understand the effect of construction noises on urban populations.

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REFERENCES