Field survey on acoustic factors of onsite football spectating

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1. Introduction

In recent years, the audiovisual contents of sports spectating via broadcasting media have greatly developed. Many kinds of new mass media are successively entering the industrial field of sports broadcasting industry, and have been changing the audiovisual environment of the remote viewing of sports. The free-viewpoint video viewing system [1,2] has also achieved practical use. Regarding audio technology, various kinds of investigations on high-quality audio capturing [3] and compression [4] technologies have been conducted as well. The reality of audiovisual contents can be continuously increased by the development of such audiovisual technology. However, first of all, factors related to the auditory and visual environments inside sports facilities that affect the evaluation of onsite sports, such as stadiums, should be clarified from the basic standpoint of the human sensation perceived by sports spectators. It goes without saying that one can experience onsite sports spectating while being very close to the players and spectators can directly cheer on the players with their voices together with other spectators. In such a situation, there may be some important factors related to the environment inside the stadium that enable the spectator to obtain greater enjoyment from onsite spectating. The acoustic factors related to the sounds generated from the players and spectators have the possibility of being included among the above factors, as well as the visual factors of being able to clearly watch the performance of the players and the whole game. There have been many studies on the sounds generated by sports spectators. The crowd noises in football [5] and basketball [6] games have been evaluated, and the effect of exposure to crowd noises on humans has been studied [7,8] as well. While most of the studies were concerned with noise levels, the noise level of the sound generated by spectators may strongly depend on the scene of the game. In addition, detailed characteristics such as the frequency characteristics and time-transient responses of spectator sounds can also be sensitively affected by the cheering voices of the spectators, but a detailed database for these acoustic characteristics has not been developed yet.

To clarify the effect of the auditory environment inside sports facilities, such as stadiums, on the evaluation of onsite sports spectating, we carried out a basic experimental study on

the different acoustic characteristics of spectator sounds for different game scenes. In addition, since the subjective impression of the excitement caused by onsite football spectating is considered to be closely related to the auditory environment of the stadium including the spectator sounds, these issues were surveyed using an onsite questionnaire given to spectators in football games.

Firstly, in order to investigate the acoustic factors that have an impact on onsite football spectating, the questionnaire survey was performed targeting the spectators of football games in the J1 and J2 Leagues of Japan. After that, in order to clarify the acoustic characteristics of the spectator sounds in some situations of football games, acoustic measurements were performed in 10 football games, and the measurement results of the acoustic characteristics of the spectator sounds are discussed in association with the questionnaire results and each scene of the football games.

2. Questionnaire survey on acoustic factors in football spectating

To investigate the effects of acoustic factors on sports spectating in stadiums, the questionnaire survey was performed targeting the spectators of football games.

2.1. Contents of questionnaire

The questionnaire survey was conducted on 132 onsite spectators that were randomly sampled from the spectators seating in the home stand during 10 J1 and J2 League football matches at nine stadiums in Japan (Table 1). We obtained 111 valid sets of answers among them (72 males and 39 females, average age: 32.4 ± 10.5). The contents of the questionnaire are shown in Table 2. Note that all the target stadiums were open-type, and the home teams of each stadium are indicated with asterisks. The questionnaire survey was carried out after the games.

2.2. Results and discussion

The results of the questionnaire survey are shown in Fig. 1. First, a large number of respondents frequently watch games onsite several times per year, and almost all the respondents already had experience of football spectating. In addition, over 70% of the respondents had experienced some kinds of sports. From question No. 3, it was clarified that over 80% of the respondents felt some dissatisfaction when watching football on TV. Among the respondents who expressed dissatisfaction, the most common response (35%) was that they cannot cheer on the players together with other

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Table 1 Target stadiums of the questionnaire and acoustic measurements. The asterisks indicate the home team of each game.

	Name of stadium	Capacity	Teams		Scores	
(G1)	Machida GION Stadium	4,000	MZ*	RY	1	0
(G2)	NACK5 Stadium	10,000	OA*	AF	3	0
(G3)	NHK Spring Mitsuzawa Football Stadium	13,000	YFC*	EFC	2	0
(G4)	Hiratsuka Stadium	14,000	SB*	GO	0	3
(G5)	Ajinomoto Stadium	14,000	TVe*	TVo	1	2
(G6)			FCT*	SB	1	1
(G7)	Fukuda Denshi Arena	15,000	JUI*	KR	0	3
(G8)	Kawasaki Todoroki Stadium	24,000	KF*	SH	2	1
(G9)	Saitama Stadium	34,000	UR*	SS	2	1
(G10)	Nissan Stadium	64,000	YFM*	FCT	3	0

spectators (option (C)), and the second common response (24%) was related to the sound environment, that is, the sounds of the spectators can hardly be heard (option (B)). Other responses were mainly related to the difficulty in seeing the players in a remote condition (options (A) and (D)). For question No. (4), the important factors required for an attractive stadiums, the options (A) and (B) related to the visibility of the players and the whole field game were indicated by 31% and 22% of the respondents, respectively, while option (C) related to the spectator sound was indicated by 27% of the respondents. Other factors related to commer-

Fig. 1 Results of the questionnaire survey; percentage of each answers to questions (a) No. (1) to No. (4) and (b) No. (5).

cial services and stadium facilities had a frequency of 20%. These results suggest that the factors related to the sound environment as well as the visual environment strongly impact the quality of football spectating. In addition, question No. (5) asked the respondents about which scenes made them most excited. The most commonly chosen four scenes were (A) scoring the goal, (B) a chance to score, (D) the team in a pinch, and (E) a fine play. In the next section, we examine

Table 2 Contents of the questionnaire.

Questionnaire	Answer
(1) Frequency of football spectating	(A) First time, (B) A few times per month, (C) A few times per year, (D) Once a year, (E) Others.
(2) Have you experienced football or other sports before ?	(A) Yes (football), (B) Yes (Other sports), (C) No.
Have you ever felt dissatisfaction in football watching on TV ?	(A) Yes, (B) No.
(3) What makes you feel dissatisfied ? (If the answer to the previous question is yes, this question is mandatory.)	(A) I can only see a limited area of the field. (B) The surrounding sounds such as the spectator voices can hardly be heard. (C) I can not cheer the players with other audiences. (D) I feel distant from the players. (E) Others.
(4) Choose the most important issue required for an attractive stadium ?	(A) The spectators can see the players close to their seats. (B) Easily see the entire field during the game. (C) The spectator sounds are efficiently transmitted to the entire of the arena. (D) The commercial services can be easily and conveniently available. (E) The spectators can comfortably watch the game due to facilities such as electronic scoreboards. (F) Others.
(5) Choose the scenes when you get excited when watching a football game.	(A) Scoring a goal, (B) A chance to score, (C) A player gets a booking or sent off, (D) The team in a pinch, (E) A fine play, (F) The players enter the field, (G) Others.

Fig. 2 Schematic of the field of the stadium and the location of the receiver set close to the home stand.

the relationship between these scenes and the acoustic characteristics of the spectator sound measured in the stadium stand.

3. Acoustic characteristics of spectator sounds

In the previous section, it was suggested that the acoustic factors in football spectating are important. In this section, the sounds generated by the spectators in football games were therefore measured and their acoustic characteristics are discussed.

3.1. Measurement scheme

The spectator sounds were measured at a receiver with a height of 1.2 m in a general stand close to but not inside the home stand, as schematically shown in Fig. 2. By setting the receiver in this location, the spectator sounds generated from the home stand can be relatively clearly recorded. Since the goal of this study was to discuss the characteristic different sound pressure levels and their time-transient characteristics in different game scenes, only the single receiving point was employed. More general characteristics of the spatial distribution of the acoustic characteristics of spectator sounds inside a stadium need to be discussed as a future work by setting multiple receivers at various points in the stands. From the recorded data, the sound data in four kinds of scenes, namely, goals, lost points, chances, and pinches, in addition to the sound of silent parts extracted as sound tracks with a duration of 5 s. These sound tracks were extracted from the time 0.5 s before the peak of the time-transient sound pressure level. These scenes are defined as follows. “Goals”/“lost points” are defined as scenes when the home team gets a goal/loses a score, respectively. “Chances” are defined as scenes when the home team had the chance to score a goal but were unable to, whereas “pinches” are defined as scenes when the away team had a chance to score but did not score. “No events” are defined as periods when the spectators in the home stand were not cheering.

In order to obtain basic knowledge of the different acoustic characteristics of these sounds, the sound tracks were converted to level waveforms, frequency characteristics, and A-weighted equivalent continuous sound pressure levels (L_{Aeq}), and the results are discussed. Note that the conversion to the frequency characteristics was performed by a Fast

Fig. 3 (a) Level waveform of the spectator sounds of each event in game No. (G2), and (b) corresponding frequency characteristics.

Fourier transform of each of the sound data with a duration of 5 s.

3.2. Results and discussion

Firstly, the level waveform and frequency characteristics of each of the scenes in game No. (G2) of Table 1 are shown in Figs. 3(a) and 3(b), respectively. Note, in this game, that the away team scored no goals, so there are no “Lost points” data. In accordance with the results, not only for “Goals” but also for “Chances” and “Pinches,” the spectators cheered or expressed disappointment almost simultaneously within the initial 2 s. There was a large level difference between the condition of “Goals” and those of “Chances” and “Pinches,” although the sound levels indicate quite similar characteristics. Secondly, the obtained L_{Aeq} values of all the games from No. (G1) through No. (G10) (15 goals, 11 lost points, 42 chances, 45 pinches, 30 scenes with on events) are shown for each scene in Fig. 4(a) and plotted against the seating capacity in Fig. 4(b). The sounds of “Goals” had the highest L_{Aeq} values, while the sounds of “Lost points,” “Chances” and “Pinches” had relatively similar tendencies. In Sect. 3.1, the questionnaire indicated that spectators felt most excited during “Goals” and “Chances,” but the L_{Aeq} of “Chances” was lower than that of “Goals.” As can be seen in Fig. 4(b), “Goals” had L_{Aeq} of as high as 105 dB when the capacity was above 24,000, compared with around 100 dB for capacities

Fig. 4 Relative A-weighted equivalent continuous sound pressure level (L_{Aeq}) values of the spectator sounds (a) for each scene and (b) in relation to the seating capacity of each stadium.

below 14,000. The same relationship between the level and the capacity was also seen for “Chances.” On the other hand, there is no increase in L_{Aeq} with the capacity. For “Lost points,” because of the limited data especially for capacities below 13,000, it is difficult to discuss the relationship with the capacity. From these results, a slight correlation was sug-

gested between L_{Aeq} and the capacity of the stadium for cheering sounds generated as a result of the home team scoring goals or creating chances.

4. Conclusion

To investigate the acoustic factors of onsite football spectating, a questionnaire survey was performed targeting at spectators of football games in the J1 and J2 Leagues of Japan, and the acoustic characteristics of the spectator sounds in 10 games were measured and discussed. From the questionnaire, it was found that acoustic factors, especially on the spectator sound, as well as visual factors including the visibility of the players and the whole field of the stadium, strongly affect the attractiveness of football spectating. On the basis of the acoustic measurement, we discussed the acoustic characteristics of the voices of the spectators, mainly focusing on the sound pressure levels and their time and frequency characteristics. As a result, it was suggested that the L_{Aeq} of the spectator sounds when the home team scores goals and create chances correlates with the capacity of the stadium.

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