Response to Experimental Playbacks of Conspecific Alarm Call in Free-ranging Japanese macaques (*Macaca fuscata*)

Atsuya YOSHIDA

Department of Psychology
Faculty of Human Sciences
Osaka University

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ABSTRACT

Alarm calls of Japanese macaques (*Macaca fuscata*) in the Miyajima group were recorded to analyze their acoustic structure by using the sound spectrograph and the FFT analyzer. The results revealed that alarm calls had acoustic properties appropriate to sound location, and suggested that relatively low range of frequencies might function as an alarm sound. Furthermore, effects of the alarm call on the behavior of group members were examined by using the playback technique under natural conditions. The results obtained in the Miyajima group indicated that playbacks of an alarm call emitted by the alpha male elicited flight and high intensity orientation responses in group members. Playback experiments of the identical alarm call were carried out in the Minoo-A group. The results were similar to those in the Miyajima group. These results would lead to the conclusion that alarm calls of Japanese macaques serve as a warning signal to conspecific individuals.

Key words: Japanese macaque, Alarm call, Playback experiment Warning signal

INTRODUCTION

Japanese macaques (*Macaca fuscata*) give alarm calls in response to predators and to humans (Mizuhara, 1957; Itani, 1963; Izawa, 1983). Itani (1963) hypothesized that the alarm calls of Japanese macaques served as a warning signal to group members of impending danger. Indeed, alarm calls of Japanese macaques seem to elicit escape behaviors by group members. However, evidence in support of this hypothesis is descriptive, and few experimental studies have been done to clarify the communicative function of the alarm call of Japanese macaques.

A more complete understanding of the effect of alarm calls on the behavior of group members requires further study of the responses of animals to such calls (Marler, 1965, 1967). However, it is difficult to study responses evoked by alarm calls under natural conditions, because predation on Japanese macaques is very rare at present. Even when it takes place, one can hardly observe a complete incident by reason of its unexpected occurence (Gouzoules et al., 1975). Playback techniques avoid these problems and are therefore useful for investigation of the responses of

animals to alarm calls. Seyfarth & Cheney (1980) demonstrated that playbacks of alarm calls of vervet monkeys (*Cercopithecus aethiops*) elicited responses in the absence of actual predators. Using experimental playback techniques, Waser (1975) found that the whoopgobbles of grey checked mangabeys (*Cercocebus albigena*) mediated inter-group spacing. Masataka (1983) reported that Japanese macaques in the Arashiyama-A group, Texas, U. S. A. appeared to respond categorically to playbacks of synthetic versions of alarm and estrous calls. But he did not investigate the precise behavioral responses to alarm calls.

The purpose of this paper is firstly to analyze acoustic structure of conspecific alarm calls of Japanese macaques and secondly to study their effects on the behavior of free-ranging Japanese macaques by using the experimental playback technique.

METHODS

Subjects

Data were collected during a four-month field study (October to December, 1981 and May, 1982) on two, baited, free-ranging groups of Japanese macaques inhabiting the western part of Japan, the Miyajima group with 70 members and the Minoo-A group with 241 members. The Miyajima group contained ten adult males older than five years, 22 adult females older than four years, 19 juvenile males, twelve juvenile females and seven infants born in 1981 (Japan Monkey Center Miyajima Branch, 1983). The Minoo-A group contained 20 adult males, 79 adult females, 53 juvenile males, 54 juvenile females and 35 infants (Yoshida et al., 1982; Yoshida & Kanazawa, 1983).

Recording and analysis of alarm calls

Recording of alarm calls was made over a three-month period (October to December, 1981) in Miyajima. The alpha male of the group was designated as a target animal for recording alarm calls. Twenty minute recordings were repeated by an observer at an interval of 30 minutes from nine to thirteen o'clock on a given day. Behavioral observations of the alpha male and identification of all the monkeys giving alarm calls other than the alpha male were simultaneouly made using videotapes recorded by another observer.

Recording of sounds was made at 19 cm/s with a SONY EM-3 tape recorder and a SONY C-74 directional microphone on SONY ULH back coated tape. Sound Spectrograms were made on a Kay digital sonagraph model 7800 using a wide band pass filter (300Hz) over the frequency range of DC-8000Hz and DC-16000Hz. A Fourier analysis of the sounds was made with an Ono Sokki personal FFT analyzer CH-400.

Procedure of playback experiments

A single bout of alarm calls was used as a playback stimulus to part of a group when at least 15 animals including the alpha male were at the group's feeding site. The animals sat on the ground to eat wheat given for the routine feeding. Alarm calls were presented at approximately normal intensity when no sound was uttered by the animals. A speaker (Fostex FE-103) was concealed in a bush at a distance of about 5–15m from the alpha male. Responses of animals occurring within three seconds of each presentation of the alarm call were observed by using portable videotape recorder. Alarm calls were presented a total of four times in each group. As rapid habituation of animals to the playback sound was expected, the presentation of the sound was limited to once or twice on each experimental day. In the case where the alarm call was presented twice a day, at least 30 minutes elapsed between the presentations. Playback experiments were conducted on November 18 & 19, 1981 and on May 25, 1982 in Miyajima. In Minoo, experiments were conducted on November 10 & 11, 1981 and on May 16, 1982.

RESULTS

Description of alarming situation and behavior of vocalizer

Fifteen bouts of alarm calls by the 15-year-old alpha male of the Miyajima group were recorded. He gave alarm calls at a distance of about 15m when a human was coming out of a tool shed with a net that was ordinarily used to capture monkeys. The alpha male fled immediately after giving the initial alarm call, periodically looking toward the man with the capture net. The group members other than the alpha male mostly looked toward the man coming out of the tool shed. Some of them fled as quickly as the alpha male did, but, most fled immediately after the initial alarm call by the alpha male. The tail-up posture was shown by the alpha male when giving alarm calls, but piloerection of the alpha male was not observed. Group members other than the alpha male never gave an alarm call. The second and third ranking males were also in the alarming situation, but they fled silently. Most of the group members including the alpha male soon gathered on a ridge at a distance of about 50m from the man with the capture net. The ridge was ordinarily used as a rest site before and after feeding in the morning. When the alpha male began to utter the alarm calls, juveniles and infants gave sounds which might be "Warbly" and "Whistly" sounds (Green, 1975).

The first bout of sequential alarm calls (the initial alarm call) by the alpha male was not used for the test alarm call of the playback experiments because that it was very faint. The second bout was designated for the test alarm call. The interval between the first and second alarm calls was 0.96 sec.

Fig. 1 shows the sound spectrogram of the test alarm call over the frequency

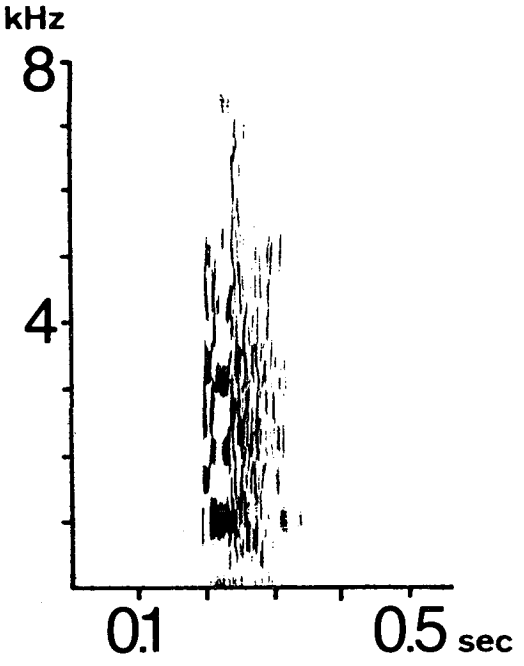

Fig. 1. Sound spectrogram of the test alarm call over the frequency range of DC-8000Hz.

range of DC-8000Hz. The two tonal segments consisting of slightly different frequency bands are followed by a noise burst. The tonal segments are seperated by the vertical lines. The total duration of the call was 0.13 sec. The duration of the tonal segments and the noise burst were 0.04 sec and 0.09 sec, respectively. The highest detectable frequency is at around 9500Hz (Fig. 2), but the power spectrum of the first 0.04 sec of the call indicates that the most energy occurs from 1050Hz to 735Hz, with a peak of energy at 1050Hz (Fig. 3). The peak energy concentration at 1050Hz is the fundamental frequency of the second tonal segment.

Responses to the playbacks of alarm call

The responses elicited by the playbacks were grouped into the following three categories. (1) Flight responses: running in the opposite direction to the speaker, running to the mother by the youngster, running to the youngster by the mother and climbing trees. The animals ran mostly at full speed with flight distance ranging from 3 to 30m. (2) Orientation responses were grouped into the following two subcategories by level of intensity. (a) High intensity orientation responses: staring and scanning. Staring was defined as occurring whenever an individual made an intense

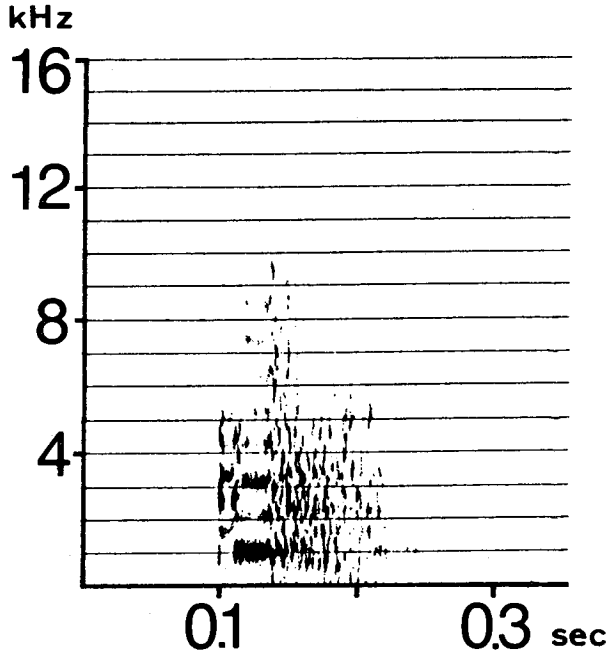

Fig. 2. Sound spectrogram of the test alarm call over the frequency range of DC-16000Hz.

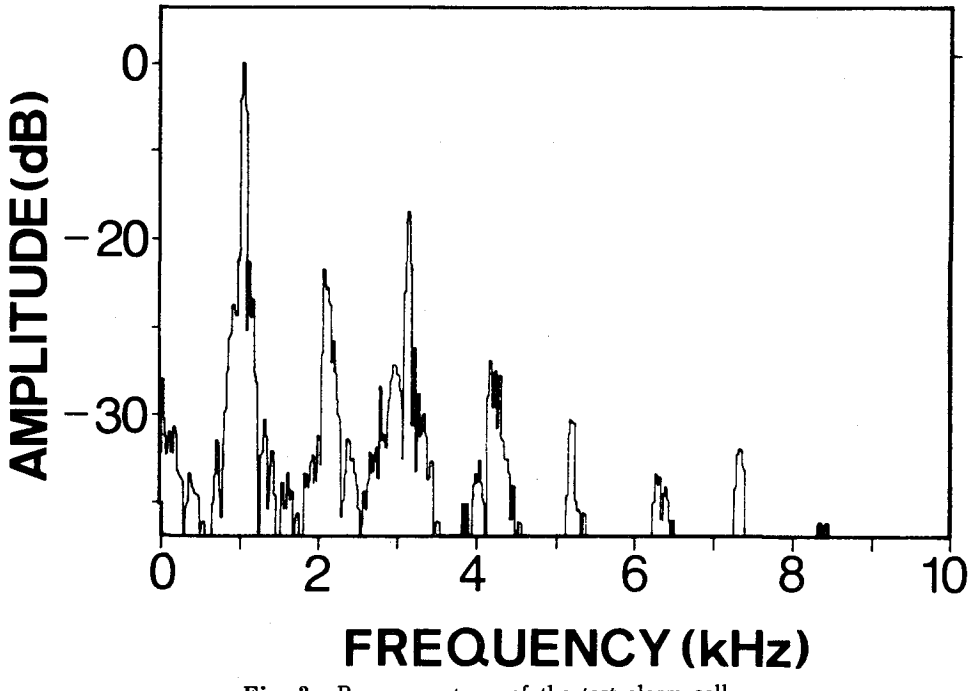

Fig. 3. Power spectrum of the test alarm call.

and quick head movement that resulted in the orientation of its face directly at the speaker, with the duration of more than one second. Scanning was defind as occurring whenever and individual made intense and quick head movements that included the orientation of its face at the speaker, with the duration of more than one second. These two responses were elicited immediately after the playbacks, and the animals showing staring and scanning to alarm calls were clearly frightened and ready to run away. (b) Low intensity orientation responses: looking and glancing. Looking was defined as occurring whenever an individual made a head movement that resulted in the orientation of its face directly at the speaker, with the duration of more than one second. Glancing was defined as occurring whenever an individual made a head movement that resulted in the orientation of its face directly at the speaker, with the duration of less than one second. Looking and glancing were elicited immediately after the playbacks, but their motions were less intense and less quick than those of staring and scanning. The animals showing looking and glancing were not frightened. In the case where the looking or the glancing was elicited half a second or more after the playbacks, it was counted as delayed response. (3) No-responses: no conspicuous responses being observed.

Table 1 shows the number of responses given by the animals to the playbacks of

Table 1 Number of responses to the playbacks of alarm calls in the Miyajima group

Session	Date	Responses			Total number of responses
		Elight responses	Orientation responses	No-responses	
1	11/18/1981	30(88.2)	4(11.8)	0 (0.0)	34
2	11/19/1981	13(65.0)	7(35.0)	0(0.0)	20
3	11/19/1981	2(10.0)	12(57.0)	7(33.0)	21
4	5/25/1982	8(42.9)	24(57.1)	0(0.0)	42

Numbers in parentheses indicate the percentages of each response to the total number of responses.

Table 2 Number of orientation responses classified by level of intensity to the playbacks of alarm calls in the Miyajima group

Session	Date	Total number of responses	Orientation responses					
			High intensity		Low intensity			
			Staring	Scanning	Looking	Glancing	Delayed looking	Delayed glancing
1	11/18/1981	4	3	1	0	0	0	0
2	11/19/1981	7	5	1	1	0	0	0
3	11/19/1981	12	2	0	3	3	1	3
4	5/25/1982	14	8	4	2	0	0	0

the alarm call in the Miyajima group. Table 2 shows the number of orientation responses classified by level of intensity to the playbacks of the alarm call. In the first session, the alarm call elicited primarily flight responses, whereas orientation responses did not occur much. The results of Table 2 indicate that the few orientation responses occurring in the first session were all high intensity staring and scanning. Similar results were obtained in the second session, but, as can be seen in Table 1, the number of flight responses decreased. In the third session, the playback of alarm calls was barely effective in eliciting flight responses. The orientation responses in the third session were mostly low intensity responses. The fourth session was carried out six months after the third session. Flight responses showed the same pattern of recovery as in the first session, but the percentage of flight responses was lower than that in the first and second sessions.

To test the effectiveness of conspecific alarm calls in an alien group of Japanese macaques, playbacks of the call recorded in the Miyajima group were carried out in the Minoo-A group (Table 3). The results indicate that the alarm call was effective in eliciting flight responses in the Minoo-A group, but to a lesser extent. In addition, the number of low intensity orientation responses increased in comparision with the results obtained in the Miyajima group (Table 4). Other than changes in the

Table 3 Number of responses to the playbacks of the alien alarm call in the Minoo-A group

Session	Date	Responses			Total number of responses
		Flight responses	Orientation responses	No-responses	
1	11/10/1981	27(50.0)	24(44.4)	3(5.6)	54
2	11/10/1981	20(39.2)	22(43.1)	9(17.7)	51
3	11/11/1681	18(37.5)	25(52.1)	5(10.4)	48
4	5/16/1982	15(46.9)	17(53.1)	0(0.0)	32

Numbers in parentheses indicate the percentages of each response to the total number of responses.

Table 4 Number of orientation responses classified by level of intensity to the playbacks of the alien alarm call in the Minoo-A Group

Session	Date	Total number of responses	Orientation responses					
			High intensity		Low intensity			
			Staring	Scanning	Looking	Glancing	Delayed looking	Delayed glancing
1	11/10/1981	24	9	0	2	3	8	2
2	11/10/1981	22	12	2	1	0	3	4
3	11/11/1981	15	9	1	3	1	8	3
4	5/16/1982	17	14	1	0	0	0	0

frequencies just noted, the Minoo-A monkeys did not show unusual behavioral responses to the alien alarm calls in the first session.

The number of animals showing the flight responses decreased by the sessions in the Minoo-A group as it did in the Miyajima group, but the decrease was not so great as in the Miyajima group. The results of the fourth session conducted six months after the third session indicate the same degree of recovery in the effectiveness of the alarm call in Minoo-A group as was seen in the Miyajima group.

DISCUSSION

The acoustic structure of the alarm call made by a male Japanese macaque consisted of two tonal segments followed by a noise burst. The tonal segments which encompassed the wide frequency range started abruptly. The fundamental frequency tof these two tonal segments was slightly different, but each of them was not varied emporally. These properties of the sound seem to be appropriate to sound location (Marler & Hamilton, 1966).

The acoustic energy of alarm calls mostly from about 1000Hz to 7000Hz occurred, although there was a wide range of frequencies. The energy was extremely concentrated from 1050Hz to 3150Hz. These results suggest that the low range of frequencies (i. e. 1-4kHz) might function as an alarm call. According to Masataka (1983), frequencies more than 7000Hz appeared to be the cue for the perception of alarm calls by Japqanese macaques, but the present results are not consistent with this view.

There were two main types of responses to the playbacks of alarm calls. One of them was flight behavior. The direction of the flight was opposite to the concealed playback speaker. This result indicates that running away from the animal giving the alarm is the response of Japanese macaques when they encounter predators. The other type of response was high intensity visual orientation in the direction of the speaker. Although only a small number of monkeys showed orientation responses, these were mainly the high intensity ones which were categorized as alarm responses. Masataka (1983) regarded flight behavior as the only response to alarm calls by Japanese macaques. He might have overlooked orientation responses because he did not use a videtape recorder.

The decrease of number of flight responses in the second and third sessions may have been due to habituation. Several researchers reported that repeated stimulation not followed by any kind of reinforcement normally resulted in a wanning of the response (e. g. Snowdon, 1979). In this experiment, flight and orientation responses were elicited by playbacks of the alarm call without the presentation of the actual predator. However, it has not been examined whether a novel stimulus, e. g., an

alarm call given by individuals other than the alpha male in the Miyajima group, would cause a recovery of the responses. Therefore, whether the decrease of responses is due to habituation or other factors is an open question.

Data presented here demonstrate that an alarm call emitted by an animal in one group (Miyajima group) is effective in eliciting flight and orientation responses in another group (Minoo-A group), although there is a difference in the effectiveness between the groups. Itani (1963) hypothesized the signal function of alarm calls of Japanese macaques from his naturalistic observation within the Takasakiyama group, but he did not examine the function of these calls between groups. The difference in the effect of the alarm call in the Miyajima and Minoo-A groups suggests that additional research be done to determine whether individual differences in the acoustic properties of alarm calls influence the responses of animals.

CONCLUSIONS

1. Alarm calls of Japanese macaques had acoustic properties appropriate to sound location.
2. Playbacks of alarm calls had the effects eliciting flight and high intensity orientation responses of the group members.
3. Alarm calls of Japanese macaques serve as a warning signal to the conspecific individuals as well as to their group members.

ACKNOWLEDGEMENTS

I thank the Board of Education of Minoo City Office and the Miyajima Ropeway Co. for permission to conduct research. I thank Mr. Tsutomu Kanaizuka for valuable help during the field work in Miyajima. I am grateful to Professor S. Nanba for his helpful advice to use the FFT analyzer. I am grateful to Professor N. Itoigawa for his helpful comments on the data presented here. I am especially grateful to Professor S. Perloe for his critical reading of the manuscript. I wish to express my thanks to Dr. T. Matsuzawa for his great encouragement to complete this work. I wish to express my special thanks to Professor Y. Sugiyama for his valuable comments on manuscript and for his kind permission to use the Sonagraph.

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