How do Young Black-tailed Gulls (*Larus crassirostris*) Recognize Adult Voice Signals?

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This study was conducted to find out how young black-tailed gulls (*Larus crassirostris*) recognize adult voice signals after hatching. For the experiment, adult voice recorded in the natural environment was played back at controlled intervals and intensity (dB) to 15 young gulls that were artificially hatched in the laboratory. The chirirah call frequency of young gulls increased as the intensity of the mew call increased. The chirirah response of the control group was highest to the mew call at intervals of 1.8 s. The adult long call and alarm call also showed similar results to the mew call when the interval and intensity were manipulated similar to the mew call. Based on the results of this experiment, it is assumed that the young black-tailed gulls recognize adult voice signals based on the simple structure of adult voice signals, that is, the interval and intensity of the voice.

Many vertebrate animals living in groups require recognition between individuals for socialization (Wilson, 1975). Birds especially perceive other individuals by integrating sensory clues such as vision and hearing (Burger et al, 1988). It is known that the basic recognition of colonal breeding species of birds depends on the auditory rather than visual senses (Stevenson et al. 1970). *Laridae* also depend on the auditory senses for most of their perception; they produce various repertoire of sounds and they transmit and receive various information by using each sound effectively (Moynihan 1958, Tinbergen 1959; Stout et al. 1969; Beer 1976). It has been found that the black-tailed gulls (*Larus crassirostris*) inhabiting Korea have 11 call sounds in their repertoire according to behavior and function (Park & Park 1997).

Studies on recognition between individual gulls began when Tinbergen (1953) published his book 'Herring Gull's World'. For 40 years since then, recognition between individuals have been studied by many researchers. Beer (1970, 1979), who observed young laughing gulls (*Larus atricilla*), reported that the recognition between parents and their chicks were formed in early stages. According to his experiments, the young laughing gulls approached their parents when they heard their sounds, while they showed caution or fear upon hearing other adult gulls' sounds. Based on his experiments, Evans (1973, 1975) reported that young herring gulls (*Larus argentatus*) and young ring-billed gulls (*Larus delawarensis*) could distinguish the mew calls of their parents from those of other adults. Holley (1984) conducted experiments on herring gull (*Larus argentatus*) and reported that the recognition between young and adult gulls after hatching was done by the young. It refuted the Tinbergen's theory (1953) that it was the adult that recognized the young. He observed and proved by experiments that herring gulls accepted young gulls from other nests in the natural setting. Young black-tailed gulls have also been found to be able to distinguish the mew calls of their parents from those of other adults (Roh and Park 1993).

The mew calls of *Laridae*, the voice signals of parent gulls calling young gulls, are very important in parent-young recognition (Moynihan, 1958). It has been well proven that young gulls recognize their parents' mew calls through learning (Beer 1969, 1979, Evans, 1970, 1980b). No studies, however, have been done on how young gulls get used to recognizing others' voice signals including their parents' mew calls in the early stage. Beer (1979) reported that young laughing gulls communicated with adults via three kinds of voice signals. Although he experimented on voice signals other than mew calls for ring-billed gulls, Evans (1986) could not explain the methods of recognition but just observed their behaviors toward each voice signal.

Young black-tailed gulls respond to adult with two types of voice signals: pip and chirirah calls (Chung 2000). They produce the pip calls when they want food and signal parent gulls to bring food (begging call, Evans 1998). The chirirah call is young gulls' answer to mew calls and its exact function has not been elucidated. It is assumed that the signals are used to let their locations be known or used for recognizing signals between siblings or parent-young gulls (Park

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and Park 1997; Chung 2000).

In this study, we have attempted to find what physical characters of parent sounds the young black-tailed gulls recognize as those of their parents. For this, we researched their recognition of parents with the chirirah call response.

Materials and Methods

The study was conducted in a laboratory from May, 1998 to July, 1999. Twenty eggs were taken from Nando Island, Gauido-ri, Anheung-myeon, Seosan-gun, Chungcheongnam-do, the breeding habitat of black-tailed gulls (36° 40′ 20″ E, 126° 03′ 50″ N). When they were collected, 7 nests with 2-3 eggs each were selected and the eggs of each nest were identified with a oil pen so that the eggs could not be mixed. This allowed the same genetic elements to stay together and each blood line in a natural state to be maintained. The eggs were hatched in an incubator (Lyon, Model RX2) maintained at 37.5±0.5℃ and 70±5% relative humidity. The incubator was equipped with an automatic device to turn the eggs every 2 h. Among the 20 eggs, 15 were hatched, and colored rings were attached to them to distinguish each individual. They were kept in paper containers (55 cm × 55 cm × 60 cm), three blood lines in the natural state in each container (5 clutch) for keeping in a remote place. The temperature of the containers was kept at 37±0.5℃ by a radiator. All young gulls were fed with yellow corvina every 2 h from 09:00 to 21:00 on a hand-held tweezer modified to mimic the bill of an adult black- tailed gull. Thirty sec before they are fed, adult black- tailed gull sounds (mew, alarm, and long calls) of the natural habitat were played back and were maintained for 1 min to increase their learning. Adult voice learning was conducted every hour regardless of feeding.

Adult calls from Hong-do, Mujuk-ri, Hansan-myeon, Tongyeong-gun and Gyeongsangnam-do (34° 31′ E, 87″, 128° 43′ 88″S) were recorded using an Uher 4000 Report IC tape recorder. Among them, the best 5 individual voices were selected to tutor young gulls. To maintain the similarity with the natural status, different adult voices were used for each breeding clutch set.

For experiments, we transformed the intervals and dB of the recorded adult sounds by using the Kay Computerized Speech Lab (Model 4300B) (Table 1). The chirirah call tapes produced in Table 1 were played to young gulls for 2 min and the responsive call rate was recorded. For the sound playback, Sony cassette recorder TCM-929 was used with a speaker installed 50 cm from the keeping places. The five age classes, which Evans (1998) used in his ring-billed gull experiment, were used (1-2, 4-5, 7-8, 14-15 and 21-22 days after hatching). For dB estimation of the playback tape, a sound level meter (Larson & Davis model 800B) was placed 50cm from the speaker. For stability of experimental objects, food was supplied 1 h before the start of the experiment.

We conducted statistical analyses with SPSS (version 9.0). We used repeated measures analyses of variance (ANOVA) and Tukey's tests with experiment wise alpha set at 0.05. A paired *t*-test was used for comparisons of difference between the control and experimental groups.

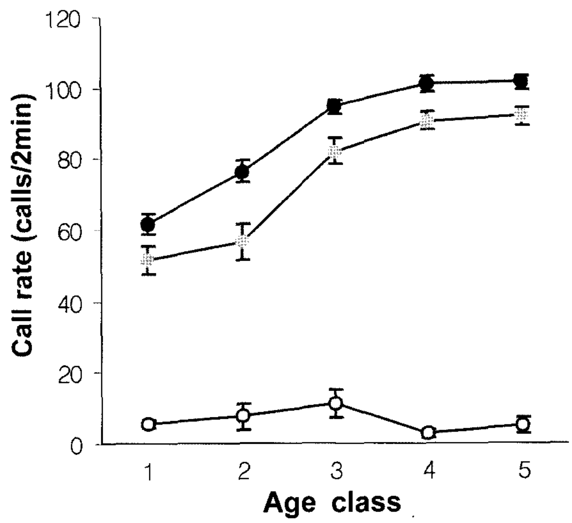

Fig. 1. Chrirah call rates (calls/2 min) of 70 dB (-○-), 90 dB(control) (-▩-) and 100 dB (-●-) mew call over five age classes of (1) 1-2 days, (2) 4-5 days, (3) 7-8 days, (4) 14-15 days, and (5) 21-22 days. Mean±SE (n = 15).

Results

The frequency of chirirah call response was highest in response to the 100 dB mew call ($F = 457.856$, $P < 0.0001$; Fig. 1). In contrast, there were little chirirah call responses to the 70 dB mew calls. However, the intensity of natural mew calls (90 dB) in the control

Table 1. Manipulated playback tape

Interval call type	Interval (s) 1			1.8			3		
	70 dB	90 dB	100 dB	70 dB	90 dB	100 dB	70 dB	90 dB	100 dB
Mew call		*		*	**	*		*	
Long call			**			*			
Alarm call				**	*				

* manipulated call, ** control call

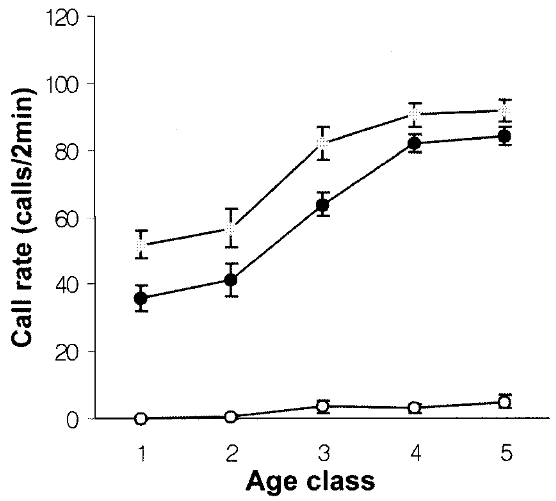

Fig. 2. Chirirah call rates (calls/2 min) of 1 s (-○-), 1.8 s (control) (-⊡-) and 3 s (-●-) mew call interval. Five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days, (4) 14-15 days and (5) 21-22 days. Mean±SE (n = 15).

group was lower than that of the manipulated 100 dB (Turkey HSD, $P < 0.0001$). Between 90 dB and 100 dB, the chirirah call response frequency of young gulls tended to increase with age ($F = 4.340$, $P < 0.001$).

The highest response frequency was observed when the mew calls (90 dB) were played back at 1.8 s intervals ($F = 276.494$, $P < 0.0001$: Fig. 2). 3.0 s intervals resulted in lower responses (Turkey HSD, $P < 0.001$). Little responses were produced in young gulls exposed to 1.0 s interval calls. The chirirah call frequency of young gulls to the mew call interval tended to increase in proportion to increasing hatch days ($F = 7.530$, $P < 0.0001$).

Young gulls showed little chirirah call responses in the natural status=parent alarm call and long call. Especially for the long call, they bent their heads and shrank to the corner. However, the response similar to the mew call (control) was shown to the manipulated 90 dB alarm call and long call (1.8 s) (Fig. 3a,b). As shown in Fig. 3, the alarm call and long call in the natural status and the manipulated 90 dB alarm call ($t = 12.935$, $P < 0.0001$) and 1.8 s long call similar to the mew call ($t = 12.428$, $P < 0.0001$) showed significant differences.

Discussion

Many kinds of gulls in their habitat keep close relationship between parents and the young through special voice signals (Stout *et al.* 1969; Witt 1977). It is assumed that young gulls can learn the parent voice signals because the signals are fixed without change (Immelmann 1969). While a young common murre (*Uria aalge*) starts to learn its parents' voice while still inside the egg (Tschanz 1965, 1968), gulls are known to learn it by contacting the adults after hatching

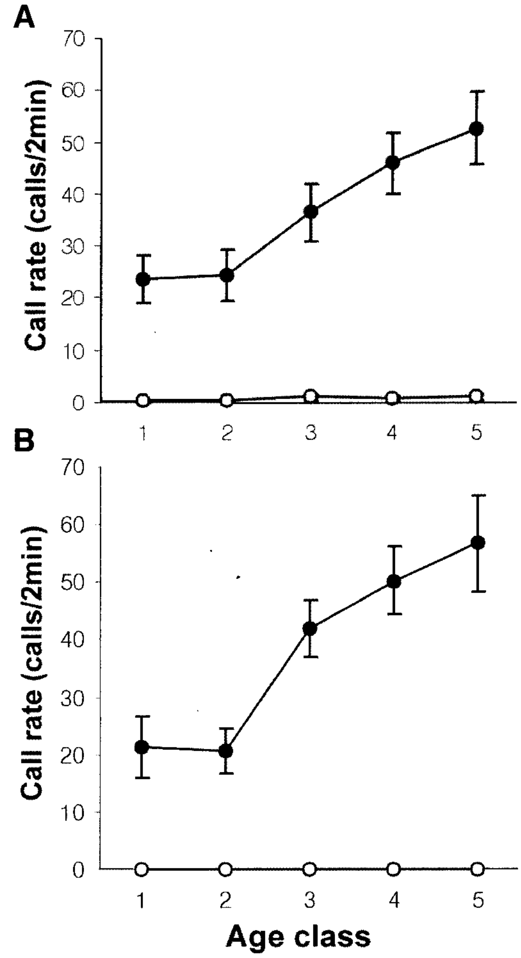

Fig. 3. (A) Chirirah call rates (calls/2 min) of controlled alarm call (-○-) and manipulated 90dB alarm call (-●-) and (B) chirirah call rates of controlled long call (-○-) and manipulated 1.8s interval long call (-●-). Five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days, (4) 14-15 days and (5) 22-23 days. Mean±SE (n = 15).

(Wooller, 1978; Beer, 1979). Accordingly, it is assumed that a young gull repeated hears and perceives its parents' voice as days go by. As for the laughing gulls, the parent-young recognition starts around 1-2 d after hatching, and the recognition increases in proportion to the hatchlings' age (Beer 1970). It has been proven that black-tailed gulls in the natural state recognize their parents' mew calls 3-4 d after hatching (Park and Park 1997). It was also shown in our experiment that the responses of young gulls to the adult mew calls in the early stages increased proportionally with age from 4-5 d post-hatching. Accordingly, like other *Laridae* (herring gulls, 5 d; ring-billed gull, 3-5 d; black-billed gull, 2-4 d; Evans 1980a), the black-tailed gull seems to learn their parents' mew calls early after hatching.

It is known that the speed of adaptation to adult voice signals in group inhabited places are closely related to the survival of young gulls (Hunt 1976). In general, those that inhabit flat fields seem to show faster recognition of parent voice signals (Evans 1980b). Of course, the clonal breeding habitat of black-tailed gulls are not flat fields. Most of them make their nests on the slopes 40-50 degrees high. The Cyperaceae plants are found densely at the height of 50-100 cm in the neighborhood of the nests. Young black-tailed gulls live within the Cyperaceae plants covered area 2-3 d after they leave their nests (Roh and Park 1993). Accordingly, the vocal contacts between parents and young gulls are unavoidable. When parent gulls arrive at the nests and produce the mew calls, young gulls respond with the chirirah calls, followed by the begging calls upon making visual contact. Our experiment also showed that young gulls responded with the chirirah calls to the parents' mew calls, indicating that development of the chirirah calls in the young black-tailed gull is closely related to the environment of its habitat. As the habitat of the black-tailed gulls is relatively sloped, young gulls often get away from their home territories regardless of their intention. At this time, the chirirah calls play an important role in increasing the survival rate of the young (Park and Park 1997). Young gulls that fall to territories of others respond with the chirirah calls upon hearing their parents' mew calls. Then, the parents keep producing mew calls until the young get out of the neighboring territory. This was verified by a manipulation experiment (in which young gulls were put into a neighboring bush) in the natural environment (Roh and Park 1993).

Then what are the parent mew calls like when young gulls produce chirirah calls? These chirirah calls are made only to respond to mew calls. Young gulls never respond with chirirah calls to mew calls not belonging to their parents or to long calls or alarm calls from parents (Park and Park 1997). Based on previous studies, it is assumed that to distinguish their parent and neighboring adult mew calls, young black-tailed gulls use physical characteristics, such as call frequency, duration and noise properties at the end of mew calls (Park & Park, 1997). However, this has not yet been proven.

It is important that young gulls distinguish the mew calls of their parents from those of other adults. But more importantly, they need to recognize the different meanings of various voice signals of the adults. Most young *Laridae* respond to various voice signals of adult gulls with different behaviors (Beer, 1970). Evans (1986), who stimulated young ring-billed gulls with various voice signals and observed their responses, reported that they responded appropriately to each category of voice signals. In our experiment, the young black-tailed gulls also responded differently in behaviors to the mew, alarm, and long calls at early stage. Chung (2000) analyzed adult voice signals by dividing them into mew, alarm, and long calls, and found that there were apparent physical differences in their call intervals and intensity.

Based on these results, particular outcomes were obtained when the manipulated tapes were played after having the gulls learn by using two physical properties. The young black-tailed gulls showed higher responses to higher intensity mew calls than those in their natural condition. The young seems to be influenced by the distance; its response may be higher to his parents's mew calls nearby than from distance.

When the mew calls were played at lower intensity like alarm calls and simultaneously in short intervals like long calls, the results were surprisingly similar to those obtained with the alarm and long calls in the natural habitat. In contrast, when the intensity of alarm calls increased to that of mew calls, and the call intervals of the long calls dropped to those of the mew calls, the results of young gulls responses were similar to those to mew calls in the natural environment (Fig. 3). Young gulls, from the early stage, especially bent their heads and shrank to the corner when the voice signals with short intervals as well as long calls were played. Accordingly, it is assumed that young gulls use the interval change in voice signals as information. The results of our experiment indicate that young black-tailed gulls adjust themselves to adult voice signals in their habitat based on the interval and intensity among the various properties of parent voice.

Young black-tailed gulls can increase their survival rate when they respond appropriately to complicated voice signals around the visually obstructed environments (i.e., thick bushes). Presumably, they learn their parents' tone quality fast and decide whether they will respond or not, by using only the simple properties of voice signals. As shown in the experiment, they responded to the interval of calls and dB of mew calls, as for their parent long calls and alarm calls. This response to stimulation can be compared with the fact that the attack trigger of male three-spined stickleback can be even crude forms of the red color, not fine forms of stickleback in the natural environment (Tinbergen 1990). After all, it may be that young black-tailed gulls selectively respond only to those necessary for their survival in the complicated voice environments. Further studies on whether the results can be applied to other young *Laridae* are required.

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Reference

Beer CG (1969) Laughing gull chicks: recognition of their parents' voice. *Science* 166: 1030-1032.

Beer CG (1970) Individual recognition of voice in the social behaviour of birds in: Advance in the Study of Behavior, Lehrman DS, Hinde RA, and Shaw E (eds), Vol 3, Academic

Press, New York, pp 27-74.
Beer CG (1976) Some complexities in the communication behavior of gulls. *Ann NY Acad Sci* 280: 413-432.
Beer CG (1979) Vocal communication between laughing gull (*Larus atricilla*) parents and chicks. *Behavior* 70: 118-146.
Burger J, Gochfeld M, and Boarman WI (1988) Experimental evidence for sibling recognition in common tern (*Sterna hiundo*). *Auk* 105: 142-148.
Chung H (2000) Behavioral development of begging and reconizing parent' mew call in black-tailed gull (*Larus crassirostris*) chicks. Ms Dissertation, Korea National University of Education, pp 1-43.
Evans RM (1970) Parental recognition and the mew call in black billed gulls (*Larus bulleri*). *Auk* 87: 503-513.
Evans RM (1973) Differential responsiveness of young Ring-billed gulls and herring gulls to adult vocalizations of their own and other species. *Can J Zool* 51: 759-770.
Evans RM (1975) Responsiveness of young herring gulls to adult mew calls. *Auk* 92: 140-143.
Evans RM (1980a) Development of behavior in seabirds: an ecology perspective. In: Burger J, Olla BL, and Winn HE, (eds). Marine Birds: Behavior of Marine Animals, Plemum Press, New York, pp 272-322.
Evans RM (1980b) Development of individual call recognition in young ring billed gulls (*Larus delawarensis*): an effect of feeding. *Anim Behav* 28: 60-67.
Evans RM (1986) Responsiveness of young ring billed gulls to various natural and manipulated adult gull calls. *Anim Behav* 34: 1668-1679.
Evans RM (1998) Begging as graded signals of need for food in young ring billed gulls (*Larus delawarensis*). *Anim Behav* 56: 79-85.
Holly AJF (1984) Adoption, parents-chick recognition and maladaption in the herring gull (*Larus argentatus*). *Z Tierpsychol* 64: 9-14.
Hunt GL and Hunt MW (1976) Gull chick survival: the significance of growth rates, timing of breeding and territory size. *Ecology* 57: 62-75.
Immelmann K (1969) Song development in the zebra finch and other estrildid finches. In: Hlnd RA (ed), Bird Vocalization Cambridge Univ. Press, London and New York, pp 61-74.
Moynihan M (1958) Note on the behavior of some North American gulls. II. Non-aerial hostile behavior of adults. *Behavior* 12: 95-182.
Park SR and Park DS (1997) Acoustic communication of the black-tailed gull (*Larus crassirostris*): the structure and behavioral context of vocalizations. *Korean J Biol Sci* 1: 565-569.
Rho JR and Park SR (1993) Recognition of the voices of the parents by black-tailed gull chicks (*Larus crassirostris*). *Korean J Behav Biol* 2: 157-161.
Stevenson J, Hutchison RE, Hutchison J, Bertram B, and Thorp WR (1970) Individual recognition by audiotroy cues in common tern (*Sterna Hirundo*). *Nature* 226: 562-563.
Stout JF, Wilcox CR, and Creitz LE (1969) Aggressive communication by *Larus glaucescens*. I. Sound communication. *Behavior* 34: 29-41.
Tinbergen N (1953) The Herring Gull's World, Collins, London.
Tinbergen N (1959) Comparative studies of the behavior of gulls (Laridae): a progress report. *Behavior* 15: 1-70.
Tinbergen N (1990) Social Behaviour in Animal, Chapman and Hall, New York, pp 57-71.
Tschantz B (1965) Beobachtungen und Experimente zur Entstehung der personlichen Beziehung zwischen Jungvogel und Eltern bei Trottellummen. *Verhandl Schweiz Naturforsch Gesell* 1965: 211-216.
Tschantz B (1968) Trottellummen die Entstehung der personlichen Beziehungen zwischen Jungvogel und Eltern. *Z Tierpsychol Suppl* 4: 1-100.
Wilson EO (1975) Sociobiology: the new synthesis. Harvard University Press, Cambridge.
Witt VH (1977) Zur Verhaltens Biologie der Korallenmowe *Larus audouinii*. *Z Tierpsychol* 43: 46-47.
Wooller RD (1978) Individual vocal recognition in the kittiwake gull, *Rissa tridactyla*(*L*.). *Z Tierpsychol* 48: 68-86.

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