Bioacoustics as a Tool for Environmental Education

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環境教育における音響生物学の応用

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Abstract ： 野生動物を題材とする環境教育プログラムでは、自然界の豊かな音響が十分に活用されていない。子どもたちが自然に対する興味関心や自然への親和的な態度を培う上で、自然界の音への気づきを深めたり、静寂の価値を知ることは有意義で、したがって音響生物学の知見は、環境教育のツールの一つになりうると考えられる。音響生物学を活用した環境教育教材による、障害のある子どもたちや、学校教育への支援について検討する。

キーワード ： bioacoustics, environmental education, wildlife, children, school curriculum

Introduction

Animal vocalizations and sounds are probably one of the most common ways that humans have historically used to identify and locate many species important for their survival. This ability obviously needs some knowledge of the species in a particular habitat and an awareness of the importance of natural sounds that is both, culturally transmitted and experientially learned. The ability to use the surrounding acoustic information is not exclusive to man though. Many animal species also eavesdrop and get advantage of other individuals' or species' communication (Fenton and Ratcliffe 2004, Beecher et. al 2007), which results in a better adaptation to their environment. In today's human populations, however, the adaptive value of natural sound awareness may not be so important in urban areas, because nature sounds are only a few compared to the amount of artificial ones, such as traffic noise.

Nowadays there are reasons other than historical ones to listen to wildlife and other nature sounds. Sound therapy, for instance, which works by reducing the contrast between tinnitus sounds and background ones (Handscomb and McKinney, 2006), is increasingly used in hospitals and public spaces around the world. Recreational reasons include ecotouristic activities such as bird watching, where practitioners take advantage of their knowledge of bird songs to locate and identify singing birds. Commercial reasons may also be linked to ecotourism, as nature guides use their knowledge of the natural sound environment in a profitable way. Likewise, scientific reasons are highly diverse. Some scientists, for instance, study animal vocalizations to understand human language evolution (Aitchison, 2000), and others to understand the origin and evolution of music (Tecumseh, 2006). The study of animal communication (animal and human sound production and reception in general), is an intense research subject that has been around for nearly a century, and eventually led to the emergence of bioacoustics, a cornerstone in our understanding and appreciation of the natural environment.

During the past few centuries, our way of living has been increasingly separating us from natural sound sources, changing almost completely the sound environment that used to be important for human survival. This disconnection may affect our appreciation of the natural environment as we stop feeling it, urging a

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need for actions that could potentially reconnect us with natural sounds, and create environmentally educated citizens. In this sense, environmental education (EE from here on) is a justifiable, although seldom recalled reason to eavesdrop wildlife and nature sounds

Nowadays, more than 40% of East Asia's population lives in urban areas (MacDonald, 2010), and the urbanization trend continues to increase. By 2050, the cities of the world will swell by 3.2 billion people (*Op. cit*.). Children growing in these environments will need many different EE approaches, available in formal and informal education, to be able to develop environmentally friendly attitudes. The use of bioacoustics as a tool for EE can be one of these approaches, providing the opportunity to feel the natural sound environment, in contrast to the unnatural sound settings of an urban area. However, traditional EE programs focusing on wildlife have seldom exploited the richness of the sound environment of which animals are an important element. In a similar way, despite the existence of bioacoustics resources in the internet available to educators, quite few serious efforts have been putted into the use of bioacoustics to foster self-determined environmental behaviors. As a result, while scientifically literate citizens may have a wide knowledge of environmental issues, their knowledge of wildlife sounds may remain limited, and their natural sound awareness may not necessarily be as good as desired.

In this paper we focus on bioacoustics as a potentially important and powerful EE tool to promote environmentally friendly attitudes. We aim at discussing some of the features and outreach potentials of bioacoustics in EE, and provide general considerations to develop an EE roadmap that begins with a deep appreciation of the sound environment.

Bioacoustics as a scientific discipline

Bioacoustics is a cross-disciplinary science that specifically investigates sound production and reception in animals, including man, and a plethora of ecological, social, and evolutionary aspects of animal sound-based communication. It origins date back to the 1800s and early 20 century, when methods existed for capturing wildlife sounds (Pavan, 2008). However, bioacoustics remained virtually unnoticed until practical recording and analyzing tools became readily available to the scientific community in mid 20 century (*Op. cit*.). In its early days, research was hampered by technological constrains such as the size of recording and storage devices as well as their fragility. However, the so called digital revolution has changed the way bioacoustics is done. Recent advances in electronic and subsequent miniaturizations of the equipments have paved the way for a bioacoustics spread (*Op. cit.*). Nowadays, it is easy and relatively cheap to obtain basic equipment for bioacoustical research, and even powerful laptops can now be used in the field along with high-end sound recorders and advanced software. These new technologies have transformed the way in witch sounds can be sampled, analyzed, stored, and accessed.

Bioacoustics and EE

In the Internet, there is a plethora of resources with wildlife sound recordings as a reference for educators and researchers. The British Library Sound Archive, for instance, has more than 150000 recordings of over 10000 species (http://www.bl.uk/reshelp/findhelprestype/sound/wildsounds/wildlife.html). Likewise, sites such as Xeno-Canto (http://www.xeno-canto.org/), and the Macaulau Library (http://macaulaylibrary.org/index.do?lk=lpro) at the Cornell Laboratory of Ornithology, altogether represent the world's largest collection of animal sounds. Resources for Japanese animals are also available, such as the library for Japanese crickets and grasshoppers sounds (http://www.nat-museum.sanda.hyogo.jp/wave/wav_koroi.html), and the site of the Japanese sicadas (http://vivace.cs.kumamoto- u.ac.jp/song.html). These web resources are readily available for educators to introduce the natural sound environment to a target audience. However, they do not constitute by themselves an EE resource. Sounds presented in these sites are usually isolated, having no

reference to the environment the animals that produce them live in, and in most cases fail to create a link between the sound-source, the animal image, and the function that such sounds do for the animal in question. As a result, the connection between bioacoustics and EE remains elusive.

In Japan, several facts favoring the use of bioacoustics as an EE tool can be recognized (Fig. 1). The main problems stem from the fact that wildlife visual materials such as picture books and DVDs are very common, in contrast to EE materials that exploit the auditory senses, witch are almost inexistent. With a single exceptional case (Oba, 2004) to the extent of our knowledge, there is no current EE program that specifically uses bioacoustics as a tool to address environmental issues in Japan. The situation in other countries is more difficult to assess given the lack of information. However, in a thorough search on the internet we came across several organizations that rely on bioacoustical information and activities (such as listening to bird songs) in their EE work. Nevertheless, their use of bioacoustics is very limited, and is not central to their programs. In the above-mentioned Japanese experience (*Op. cit.*), a series of courses to learn about the sound environment were offered to parents and children. Sounds such as those from birds, frogs, cicadas, crickets and bush crickets were used for the training. For schoolteachers and local nature guides, a special course on nature sounds and basic bioacoustics research skills was also offered. These experiences resulted in a positive reaction from local citizens. However, it was evident that without a proper educational and outreach strategy, the public will remain difficult to reach (Oba, 2004). As a possible solution to increase awareness, it was proposed to involve local primary schools to promote the use of bioacoustics in the curriculum (*Op. cit.*).

Bioacoustics in the school curriculum

Including a new subject in the school curriculum could be a difficult task. Oba (2004) outlined the characteristics of a learning program in formal education to listen to nature sounds. He suggested that it should be a step-by-step procedure, designed to cope with the different stages of development and varying degrees of outdoor

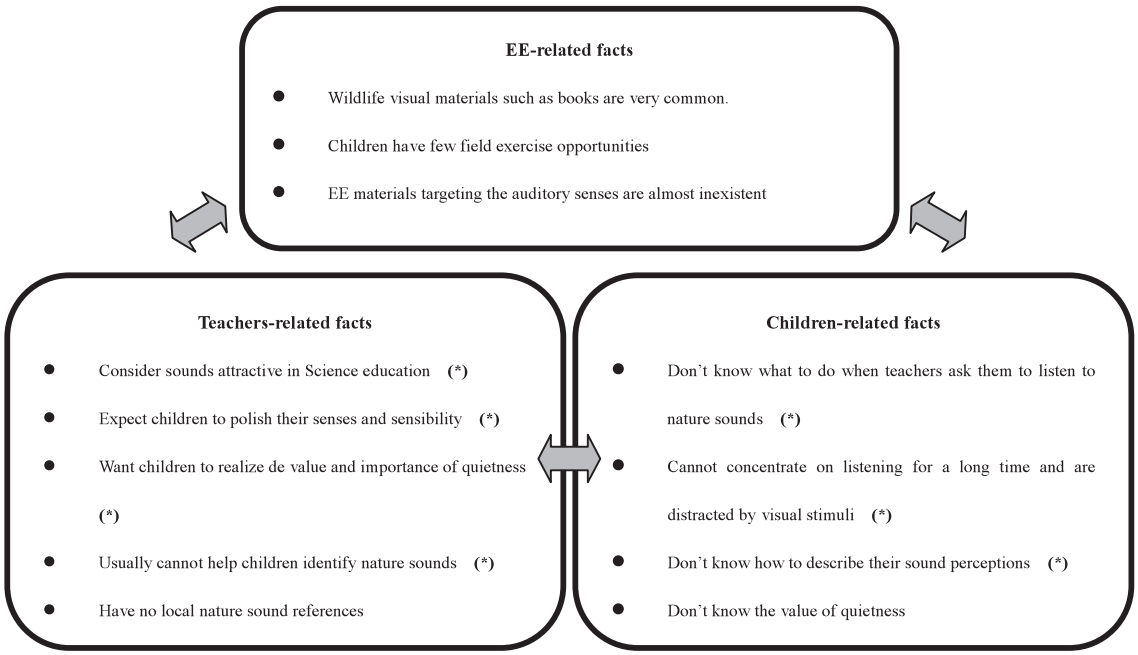

Figure 1 : Facts favoring the use of bioacoustics as an EE tool in Japan. Arrows indicate the direction in witch facts affect each other. (*) Oba (2004)

experiences. This is an important consideration from the cognitive development theory stand point (Jacobson et al., 2007), as children go through different developmental stages in which their capacity to acquire certain knowledge, particularly putting abstract concepts into practice, varies. Therefore, any EE program using bioacoustics as a tool should be carefully planned and adapted to the needs of each age group, going hand in hand with other age related curricular activities in the school. Animal sounds are attractive to children and in some cases easy to learn and remember. However, associating sounds with animals in the field when other species sounds and undesirable noises abound, and relate them to ecological and other environmental knowledge could be very difficult for children under the age of 10 (fifth grade) (*Op. cit.*).

Using bioacoustics to promote an environmentally centered intention to act (IA) in school children

Oba (2004) has stressed that an EE program involving bioacoustics must have a long-term perspective for the 6-year primary school curriculum, while offering practical learning modules with several choices and variations to fit in with daily teaching. These considerations, while being critical in attaining an IA in school children, are not necessarily enough. Other factors, recognized as necessary for an EE to be successful in promoting an IA in environmentally friendly ways, must be also considered (see Darner, 2009), including: 1- Children involved as active, rather than passive, participants in learning process; 2- Formal EE preferred over informal EE; 3- Longer EE programs; 4- Incorporation of community wide efforts into classroom efforts; and 5- Incorporation of action training in EE.

Bioacoustics offers many opportunity windows that can be used to attain the above mentioned factors. First, school children are not only to be introduced to new nature sounds; they also produce sounds that can be used as study materials. The fact that all individuals have a different timbre when talking even if they match the same pitches makes our voices to be unique. This implies that active participation in an EE using bioacoustics begins with the recognition of individuality as an encouragement to investigate the world of sounds. Second, bioacoustics can be incorporated into the school curriculum as a complement to music education, and reinforced in extracurricular activities available to all grades. Third, given that noise contamination is a common problem in all urban areas around the world, of which Japan is no exception, community wide efforts to reduce noises can be brought into the classroom through activities such as the elaboration of neighborhood sound maps, and the restoration of bird communities by setting nest boxes in green areas and parks around the school. These activities in turn serve as action training in EE for children. The use of bioacoustics in EE to promote self-determined proenvironmental behaviors should also include ample opportunities for students to actively solve environmental problems of their choice, and give them the choice on how to act, rather than provide them with instructions (Darner, 2009).

Promoting wildlife sound awareness and conservation through bioacoustics in EE programs

It is often the case that animal sounds are the only reference we have of a species occurrence in a particular area. This is because most animals can usually be heard before they could be seen, particularly in cluttered environments such as different kinds of forests. This is, of course, under the assumption that our hearing perception and sound awareness is well developed. In Japan, animal sounds such as those of cicadas and birds are widely known. Cicadas sing so laud that they are probably impossible to ignore. However, attractive as they may be, there are many wildlife sounds that are totally unknown or even unconsciously ignored. For instance, in large urban areas of Japan such as Sendai city, mating calls of the bat Nyctalus aviator can be heard even around Sendai Station. It is a laud call that is emitted several tens of meters above the ground (Fukui, 2009)

rendering visualization of the bat nearly impossible. For this, its call has been coined as “nazo koe” or “mysterious voice”. Nazo koe is probably one of the many examples of wildlife sounds ignored due to people’s focus on other sounds, such as traffic noise, or people’s failure to notice different sounds, better translated as a lack of sound awareness. By taking animal sounds as the unit of attention, wildlife sound awareness as well as sound pollution awareness are among the things that can be achieved in a Bioacoustics-EE program.

The bioacoustic approach to EE also offers noticeable perspectives on nature protection and conservation (Oba, 1999), by imposing the least cost and damage upon living organisms in the processes of monitoring. It also offers an important ecological viewpoint in the evaluation of quietness, a concept that is usually difficult to perceive by children living in urban areas. Likewise, this approach offers unique opportunities to study very elusive, usually endangered animals, in a noninvasive way. It also allows extracting the information about complex biological activities and different environmental phenomena from the composition and delivery pattern of natural sounds (*Op. Cit.*), with minimum impact to wildlife.

Outreach potential of bioacoustics in EE

The use of wildlife sounds to introduce school children to the animals that produce them, as well as deepening children’s knowledge of wildlife‘s environment, ecological networks, threats, etc., has a high potential to change children’s attitudes towards nature. There are many potential activities in which children can engage either at the classroom or in the field. The attractiveness of wildlife sounds appeals to children’s imagination as they try to guess how an animal may look like, how it lives, and how it interacts with other organism and the environment, while stimulating students to make observations using the sense of hearing, rather than the usual sense of sight.

As animals can be heard even if they are not seen, the sense of success that children get after a field experience

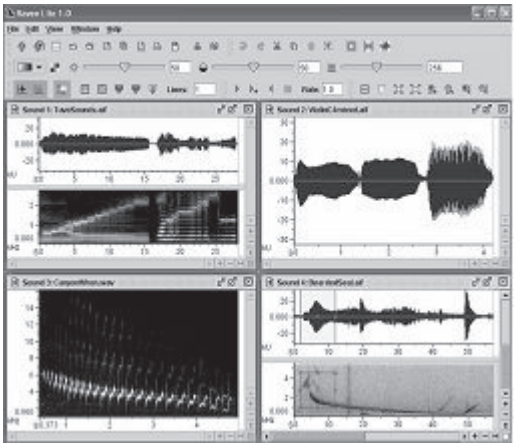

Figure 2: Graphical depictions of sounds are abstract, but didactic representations that allow deft children to “see” and appreciate the richness of the natural sound environment.

hearing animal sounds should remain high, becoming a source of inspiration and respect for nature. Moreover, children with limited vision or even blind can fully participate in EE activities involving animal sounds such as nature walks. Likewise, children with mental retardation, especially children with autism for who sounds are especially attractive, would also benefit from participating in this activities. At the same time, given the positive (healing) effects that nature sounds have on humans (Handscomb and McKinney, 2006), it is possible to create relaxing environments at school with the sounds to which children are introduced, extending the influence of bioacoustics not only to the class hours but to other recreational activities as well. In these healing experiences, animal and nature sounds could be purposely listened at for relaxation and appreciation of the recreational value of nature. Similarly, because special software allows us to visualize wildlife sounds (Fig. 2), even hearing impaired children can benefit from an EE program based on animal vocalizations. Each sound in nature will have a visual match that is both, fun to see and play with.

Technical constrains

Although there is basic equipment for research

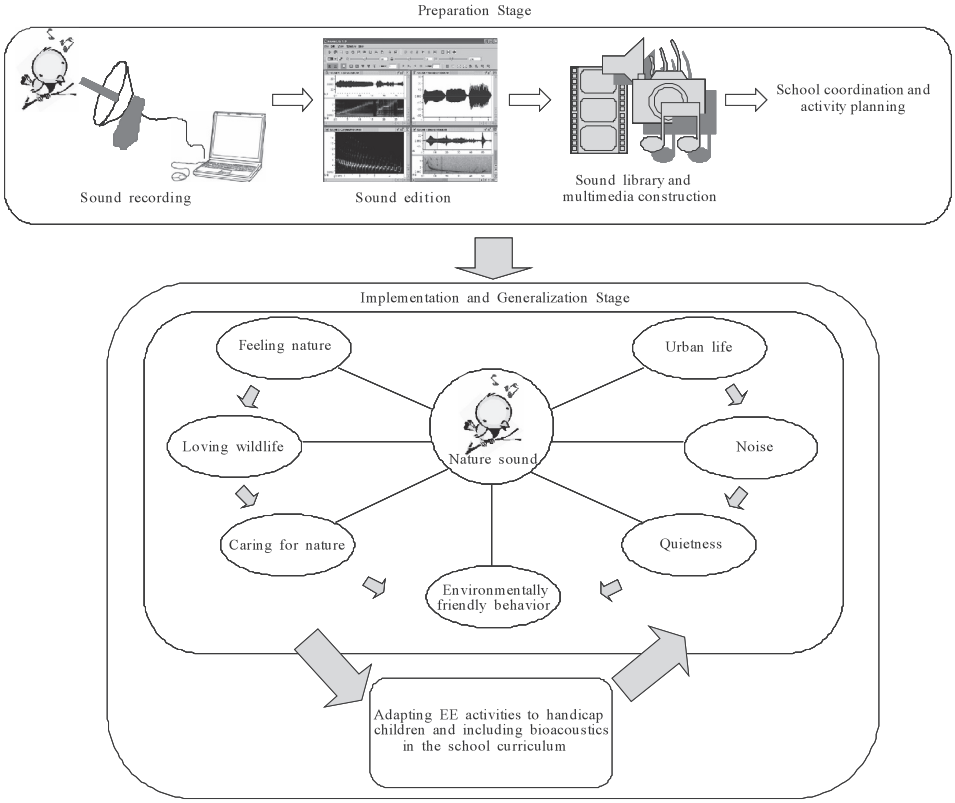

Figure 3: Stages of a bioacoustic-EE program. In the implementation stage, EE activities should meet the different needs and learning capabilities of children from grades 1 to 6, going from simple experiences such as feeling natural sounds and understanding the urban way of life, to more complex experiences such as understanding the value of quietness and care for nature. Continuous feedback between school and field experiences in the implementation of activities, and their generalization to a wider audience (including handicap children), serves as a basis for including bioacoustics in the school curriculum.

available in affordable prices, bioacoustics can be technologically demanding, and in many cases a very expensive science. As basic equipments we understand a tape recorder and a PC for sound analysis. However, wildlife sounds are not isolated, and usually recordings are affected by noises other than the desirable animal sound. Isolating an animal sound requires sophisticated directional microphones, and posterior edition in commonly expensive software. This also makes the process of sound acquisition a time consuming endeavour. Fortunately, once a wildlife sound library is completed, sound reproduction and sonogram visualization can be done with simple, free software available in the Internet, such as Raven Lite (http://www.birds.cornell.edu/brp/raven/RavenVersions.html#RavenLite).

A bioacoustics-EE program outline

A program focused on introducing school children to animal sounds and vocalizations should pave the way for teaching them more profound ecological concepts such as habitat, niche, ecological interaction, food chain, behavior, species conservation, and sustainable development. However, the primary focus includes the realization of the natural sound environment, and giving children an opportunity to feel nature with their hearing senses, and understand the value of quietness (Fig. 3). The program should not be limited to wildlife sounds, as there are many natural sounds that are part of the environment in which animal live in. Furthermore, it should be designed to also reach children that because of their disabilities are often unable to participate in EE activities. The program should also be implemented in rural and urban areas in order to reach children with many different backgrounds.

Before any bioacoustics-EE program begins, natural sounds should be thoroughly sampled and edited into a

sound library. The role of universities in this regard is very important. Bioacoustics requires knowledge and training, and in order to produce practical EE materials, research has to take place. In areas such as Miyagi Prefecture, where bioacoustics research is almost inexistent, the basis for a bioacoustics-EE program should begin with intense sound recording surveys. Information qathered in these surveys should be used to produce easy-to-use, readily available sound and other multimedia materials. These materials in turn can be used by primary schools to develop their own bioacoustics-EE programs, under professional guidance.

The above mentioned considerations have several implications for the implementation of bioacoustics-EE programs in both, formal and informal education. In general, this implementation can be achieved in several stages of development (Fig. 3), which includes:

1 —Preparation stage: Animal and nature sound recordings take place (field work) by bioacoustics professionals based at universities or other research institutions. A database is build, containing the recordings along with a bank of related information that will be used in EE activities.

2 —School engagement stage: Selected schools are engaged in EE activities that will use the materials prepared during the preparation stage.

3 —Generalization stage: The EE activities carried out during the engagement stage are adapted to make a general EE program based on animal and nature sounds, applicable to both, normal children and those with physical or mental disabilities. In this stage, the longest one, feedback from activity experiences is very important, and the basis for including bioacoustics in the school curriculum should be defined.

Conclusions

Bioacoustics provides a venue to experience nature through the hearing senses, and offers ample opportunities for self –determined, environmentally friendly behaviors to develop in school children. Its outreach potentials goes beyond that of traditional EE programs, by including children that because of their physical or mental disabilities has been usally neglected. For this potential to realize, however, the inclusion of bioacoustics as an EE tool in formal education must be attained. In Japan, conditions favoring this inclusion exist, although it may take several years for it to take place. This is because of the different stages of development which a bioacoustics-EE program must go through in order for it to be successful in fostering environmentally centered IA in school children.

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