

## Childhood Hearing Loss: The Role of Multimedia Auditory Training Tools

Following diagnosis, one of the critical elements of the successful habilitation of a child with a hearing impairment is the fitting of advanced hearing instruments. After appropriate hearing aid fitting, the child needs to learn to make use of this new rich auditory input. There are many tools to enhance this lifelong process. One of these is the use of multimedia computer tools in the home. Otto's World of Sounds is a new multimedia auditory training tool from Oticon, which allows for the family and child to be active partners in this habilitation process. This article demonstrates the benefits of using Otto's World of Sounds to augment traditional intervention provided by their speech language therapist, teacher of the hearing impaired, and audiologist.

For the child born with normal hearing, learning speech and language is a natural process. From the moment a child is born, he/she is immersed in language stimulation. Family and others in the child's environment provide the child with speech via the auditory (and often) visual modalities. Unless hearing loss, language or other cognitive abnormalities are present, the child will learn to perceive speech and language via the auditory channel and will begin to actively produce speech. The child's speech and language will constantly expand through a process of turn-taking and language use (request, protest, label, comment, greet, and call attention). Soon the child will understand how effective spoken language can be at controlling his/her environment. Importantly, speech and language are learned in a natural manner: the role of speech as a tool in communication and in the relationships between people is made obvious.

When the child is challenged by hearing loss, either from birth or occurring early in childhood, the natural process of learning speech and language is impeded. Children are not able to 'overhear' information from various sources. This deprivation from input delays their speech production, language development, vocabulary acquisition, and world knowledge (Carney & Moeller, 1998). A decrease in audibility associated with a hearing loss does not allow access to all acoustical speech cues, which negatively effect speech and language development in children.

The impact of the hearing loss on speech, language, and auditory development is dependent on the severity of the hearing loss. The greater the hearing loss the greater the potential delay in these crucial skills. For a child with a hearing impairment, remediation is required, which consists of the fitting of an appropriate advanced hearing instrument coupled with targeted habilitation. An advanced hearing instrument restores the audibility of the important speech and language cues for the child, and is essential to maximizing the child's speech, language and auditory development.

## The Need for Intervention

For a child with a hearing impairment whose family has opted for an oral based educational experience, a dedicated professional effort allows the child to achieve his/her full speech, language and auditory potential. In cooperation with the child's family and teachers, a professional team is assembled and an intervention program is put in place to compensate for the impaired speech and language learning process. This process usually requires stimulation, modeling, feedback and reinforcement in many different environments throughout the day. Direct lessons in a structured therapy session are usually not enough. Most professionals agree that direct intervention needs to be supplemented by activities in everyday settings (e.g. during school, during social activities, at home with the family).

### **Building Blocks**

A common approach to speech and language intervention incorporates a skill building sequence to auditory development: basic, fundamental processes are introduced and practiced before moving to the development of advanced abilities. For example, ensuring that the child can discriminate speech and non-speech sounds would be a more fundamental step than identifying a non-speech sound. Following the descriptions by Erber (1982), Ling (1989), and Estabrooks (1998) Table 1 provides a hierarchy of sound perception skills, moving from fundamental to complex.

**Table 1: Hierarchy of sound perception skills**

<b>Detection</b>
<b>Discrimination</b>
<b>Identification</b>
<b>Comprehension</b>

The following situation (Table 2) has been interpreted for each of the following building blocks.

A child is at preschool and the teacher is taking attendance for the day and calling out each child's name. The child's name is Sam.

**Table 2: Examples of behavior for the different blocks in the hierarchy**

<b>Detection</b>	Sam turns his head each time a name is called out by the teacher.
<b>Discrimination</b>	When the teacher calls out his name and a classmate's name (Sam and Stephanie), he can distinguish between his name and the other name called.
<b>Identification</b>	When the teacher calls out his name, Sam turns his head towards her and says "Sam".
<b>Comprehension</b>	When the teacher calls out his name, Sam responds to the teacher and says "I am here."

Although other naturalistic immersion techniques do exist, the building block approach has a variety of advantages. For example, professionals and families can be sure that the child can make broad distinctions before focusing on more detailed skills. The child is more likely to receive positive reinforcement early on if the required skills are basic.

Within each major skill block, more defined skills can be identified. In the discrimination block, one such skill is the ability to distinguish between different, non-speech sounds. Speech is a complex auditory signal - there are many different sounds in a word. There is usually energy present at many different frequencies, with the location and intensity constantly changing. Many of the most important speech sounds are rather brief and oftentimes, the referent or context is not apparent. Making sense of speech requires some rather sophisticated analytical skills. In contrast, many environmental sounds are simpler in nature. They can often be longer in duration and less complex acoustically. The relationship between the source of the sound and the sound itself is often quite apparent.

For a child in the earlier stages of auditory development, learning to detect, discriminate and identify common environmental sounds can be a rewarding experience. As a child is challenged to find the benefit of using the auditory channel, their discovery between an auditory event and the object or event in the environment that caused it can be important reinforcement. The child learns that there is meaning associated with sound. As this revelation unfolds, the child will naturally start to search for more and more of this type of stimulation, eventually leading to the development of perceptual speech skills; thereby making sound object associations in their everyday world.

## ***The Unique Opportunities of Multimedia Tools***

Research demonstrates that the use of multimedia-based instruction increases the speech, language, and auditory skills in children with hearing impairment (Mander, Wilton, Townsend, & Thomson, 1995; Prinz & Nelson, 1985; Prinz, Pemberton, & Nelson, 1985, Pratt et al, 1993, Schopmeyer, et al, 2000). The use of computers is a valuable augmentation to traditional speech and language intervention programs (Seal, Rossi & Henderson, 1998), as individuals with speech and language impairments prefer using them (Ott-Rose & Cochran, 1992).

Although it is useful for children to learn the relevance of sounds in their natural setting, the multimedia capabilities of modern home computers offer a unique opportunity for the auditory development process. In a controlled manner, the correspondence between a sound and the associated source can be presented to the child. The sound reproduction capabilities of most current generation computers are clearly sufficient

to provide the child with high quality auditory stimulation in a controlled context. Although no substitute for direct, professionally mediated training or experiencing sounds in the natural environment, multimedia, child-directed auditory training software can add a new, interesting component to the rehabilitation package. The multimedia can give the family ideas of sounds that the child knows and which ones he/she does not know.

## **The Development of The Blue Mouse**

The potential advantages of performing auditory training for children with hearing impairment using computer-based multimedia tools became obvious to Alain Vinet, an audioprothésiste (audiologist) in Paris, France. Mr. Vinet is a specialist in fitting hearing aids to children and he is part of a professional community in France (Collège National d'Audioprothèse) interested in providing the very best developmental experience for children with hearing impairment. Mr. Vinet and his colleagues became convinced of the need to provide structured, high-quality auditory training for these children. He was also struck by the lack of useful tools in his home country. Along with colleague, Mr. Denis Barbier, an engineer and computer scientist, he therefore started the company LAA Multimédia – today Audivimédia. They created a computer-based auditory training program to be used by speech and hearing professionals engaged in fostering the development of young, hearing impaired children, especially those with severe and profound losses. The result is a French-language software program called La Souris Bleue (The Blue Mouse).

The Blue Mouse is a structured auditory training program designed to build basic sound discrimination and identification skills in young children. The program is comprised of eleven different auditory environments (e.g. The Home, Musical Instruments), with eleven sounds in each environment. The child can complete a variety of different discrimination and identification tasks with these sounds under the direction of a professional. The child's progress across sessions is tracked, with the child being required to complete fundamental skills before moving to complex skills. The structure of the screens and navigation is such that the child him/herself can navigate. This visual and operational design makes the auditory training session feel very much like a game to the child. It is stimulating, challenging and engaging. The Blue Mouse has been so well accepted by professionals in France that essentially all children who receive auditory training intervention are taught using The Blue Mouse program.

## **The Development of "Otto's World of Sounds"**

Given the success of The Blue Mouse in France and given the need for high quality auditory training materials in other parts of the world, Oticon decided to participate in the development and production of an at-home version of The Blue Mouse for use across the world. The new multimedia-based auditory training program is called 'Otto's World of Sounds'.

The following principles guided the development of this new software tool:

- To involve the parents in the developmental process.
- To use a game approach which engages the child.
- To use a monitored progress approach, which provides motivation to the child.
- To expand the complexity of the tasks as the child demonstrates skill acquisition.
- To make the set-up, entry into and progress through the software intuitive, in order to maximize the ease of use for parents and so that the child him/herself will eventually be able to use the program independently.

Since intervention programs vary from country to country, it was not Oticon's expectation that Otto's World of Sounds would form the basis of a professionally mediated auditory training program. Rather, we envisioned that Otto's World of Sounds would supplement in the home what the local professional teams already use with children. We have developed Otto's World of Sounds as a tool that the family can use with their children (around 2½ to 10 years old) at home to further provide sound detection, discrimination and identification experiences in a fun, easily accessible format.

Like The Blue Mouse, Otto's World of Sounds consists of different auditory environments, 10 in all, each with 10 different sounds. All of the sounds are environmental, as this program is designed to foster the development of fundamental sound detection, discrimination and identification.

For each of the sounds in the program, a corresponding picture is available. For example, for younger children, bright, stylized drawings are used to depict the sound source. For older children with emerging reading skills, the sounds are also represented by words.

Within each of the ten sound environments, there are several different activities, including discovery (in which the child can choose from a variety of objects in the environment to discover what sounds they make); memory (in the classic game style of finding matched pairs of sounds); and recognition (in which the child hears a sound and must then find the corresponding object). The game is structured in such a way that the child must first experience a sound via discovery before that sound can be used in a recognition activity. In addition, within each activity, the complexity (as indicated by the number of sounds used during any one session) increases based on the child's experience in that environment. The child's progress is saved from session to session.

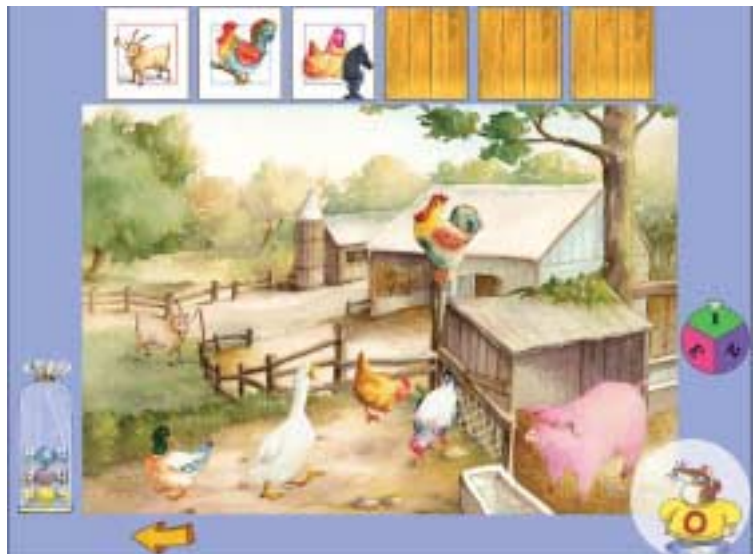
Figure 1 shows the discovery activity for the 'Bathroom' environment. In this example, there are eight possible sounds to find and the child has already found three.



Figure 2 shows the memory activity for the 'Garden' environment. There are four pairs of sounds and the child has already matched the first one.



Figure 3 shows the recognition activity for the 'Farm' environment. In this example there are 6 different sounds and the child has identified three.



The program is designed for up to 3 registered players and 1 guest player. The progress of a registered player is saved for future games whereas a guest player (family members or friends) can play without having their scores recorded. The family can provide a model for the child when first being introduced to new sounds or a new game.

Intermittently, as the child works his/her way through the different activities within each of the environments, he/she will receive a puzzle piece as an award. The child can then go to the puzzle page and place this piece in the appropriate spot. The child needs to work his/her way through all of the environments and all of the activities in order to complete the entire puzzle.

## **Initial Clinical Results with Otto's World of Sounds**

Seven speech and language therapists in France used Otto's World of Sounds in habilitation with thirteen children with hearing impairment (children ranging from two to twelve years of age with moderate to profound hearing impairment).

After seven months of use, the speech and language therapists and children noted several positive outcomes. The children enjoyed being able to hear the sounds and show their competencies to others and themselves. Several of the children with profound hearing loss obtained 100% recognition of the sounds after two months of using Otto's World of Sounds three times per week.

Being able to perceive sounds gave them assurance to wear their hearing aids, as without wearing them they could not recognize the sounds. This led directly to the children's increased acceptance and ownership of their hearing aids. Additionally, auditory curiosity led to the children's increased maintenance of their hearing aids. They were also very confident with the computer program as it progresses from fundamental exercises to more challenging tasks at the child's pace to ensure confidence and success.

Children were engaged in the program, loved the awards and eagerly waited for the puzzle pieces at the completion of a level. In addition to a significant change in auditory skills and hearing aid acceptance, the speech and language therapists identified an increase in speech production in some of the children.

## Use of Multimedia Strategies at Home

Otto's World of Sounds is a fun and useful supplement in the home to the intervention program that is provided by the team of professionals responsible for the hearing impaired child's auditory development. Otto's World of Sounds is perfect for targeting beginning auditory development, and can be utilized throughout the child's auditory development. It easily adapts to the child's auditory developmental progress, as it includes programs to challenge advanced auditory skills, (e.g. auditory memory).

The program was designed to be easy to install and use, in an attempt to minimize potential barriers to use by the family. In fact, the experience of Mr. Vinet and Mr. Barbier with both The Blue Mouse and a development version of Otto's World of Sounds is that the children themselves are motivated to engage in it and find it easy enough to activate and navigate.

It has been demonstrated that children aged 2½ to 10 years old have enjoyed it, but older children might enjoy it as well, dependent on the child's auditory development. Experience in France indicates the value in having the family participate with the child in using Otto's World of Sounds. First of all, the family can now act as part of the intervention team. There is no doubt most families want to be an active part of the intervention program for their child with a hearing impairment. This program opens up another avenue of active participation and the concept can also be extended to siblings or even close friends of the child with hearing loss. Further, by participating in the auditory tasks, the family is provided with a clear indication of the auditory capabilities of the child. In some cases, families may have unreasonably high or low expectations for the auditory skills of their child. This program gives them an indication of the child's auditory abilities versus their own expectations.

The structure of the program, using increasing complex stimulus as well as feedback/reward is designed to keep the child engaged and motivated. Again, experience during development of Otto's World of Sounds in France has clearly demonstrated that the game presentation of the program serves to motivate the child to come back to the program time and time again. With ten different environments and ten different sounds and four activities in each, there are many hours of potential non-redundant interaction with the program, thereby providing many opportunities to increase the child's auditory abilities. The child will progress through the program at a self-determined pace that is dependent on the child's developmental age and hearing status. The individualized pacing is designed to minimize the likelihood of either frustration or boredom.

## **Conclusions**

There is no doubt that hearing impairment presents a challenge to children and their family as it delays acquisition of speech, language, and auditory development. It limits the accessibility of auditory information to the child. With this reduced input, children need directed intervention to maximally use their auditory channel and develop speech and language. This intervention cannot be limited to pre-defined, traditional therapy sessions. Rather, the rich auditory experiences of everyday life need to be used as part of the child's developmental experience, as they must gain an appreciation of the meaningfulness of sound. Having an at-home, game-based tool is a great way to extend the child's intervention program to a less formal, readily accessible setting in which the family, and perhaps even friends can be included.

Otto's World of Sounds provides such a learning environment. Ten different auditory environments are provided for the child, each focusing on 10 different sounds. To foster the development of fundamental sound detection, discrimination and identification, all of the sounds are a representation of sounds that children encounter in their daily listening experiences. Within each of the ten sound environments, there are several different activities, including discovery, memory and recognition. The game is structured so that the child must first experience a sound via discovery before that sound can be used in recognition. In addition, within each activity, the complexity (as indicated by the number of sounds used during any one session) increases based on the child's experience in that environment.

Through the use of Otto's World of Sounds, the professional and family can provide a fun supplement to the child's intervention program, as there is no substitute for direct training or experiencing sounds in their natural environment. It is a child-directed auditory training software that adds a new, interesting component to intervention.

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