

# Field Study News

## FM usage of children with autism spectrum disorder

Improvements in concentration, communication, eye contact and motor restlessness

### Abstract

During the last few years, staff at the Kollegievejens School in Aalborg, Denmark, have worked on a hypothesis which suggests that by stimulating the auditory sense in people with Autism Spectrum Disorders (ASD), attention and concentration can be enhanced. With this approach, improved sensory integration can be obtained.

In this study, an open-fit ear level FM-receiver (Phonak EduLink) was worn by the pupil, and the staff member carried a wireless FM microphone, increasing the volume and signal to noise ratio of the staff member's voice. The purpose was to give ASD pupils the proper conditions in which to advance learning and educational possibilities.

25 pupils with ASD participated in the study. The study investigated 4 main focus areas, divided into 9 subcategories. In all subcategories an improvement was seen and in 7 out of 9 subcategories an improvement was seen in 60% or more of the children. It can be concluded from the study that, on average, by stimulating the auditory sense the pupils' concentration and attention spans improved, language usage and communication improved, eye contact improved and stereotypical body movements improved.

### Introduction

In the International Classification of Diseases ICD-10, Autism Spectrum Disorder (ASD) is defined as a pervasive developmental disorder with impairments in the following areas:

- Impairment in social development
- Impairment in communication
- Stereotypical and repetitive behavioral patterns

Today, it is recognized that ASD is innate. Impairments in the above mentioned areas occur at a stage of the child's development, where development of crucial skills is normally expected.

An important prerequisite for the development of social relationships is attention. The concept of attention includes the ability to obtain and maintain concentration. Furthermore, it includes the ability to focus one's attention on specific stimuli and excluding distracting stimuli.

Attention, concentration, and perception are fundamental to optimal cognitive functioning. Cognition indicates all the

processes that are active when the individual perceives senses, acts, thinks, feels and remembers. Cognitive functions exist in connection to the external world. This study is, among other factors, based on the assumption that ASD has a fundamental impairment in sensory integration, which causes limited concentration and attention abilities.

Sensory integration is the most important form of sensory processing. It collects and organizes all sensory perceptions so that experiences can be perceived in a holistic context. For an individual to develop and adapt to its relational environment, the brain must be able to organize sensory input. When children with ASD have difficulties adapting and adjusting to their surroundings, this may be due to the brain having difficulties perceiving and categorizing sensory inputs, thus inhibiting optimal sensory integration.

The criteria/terminology for autism will change in the next Diagnostic and Statistical Manual of Mental Disorders (DSM). Publication of DSM-5 is due in May 2013 and will mark one of the most anticipated events in the mental health field. In this publication all current subsets of ASD (autism, Asperger's, Rett's) will all be called ASD. Researchers found that the distinctions among various disorders were inconsistent and they feel that autism is best defined by a common set of behaviors, represented by a single diagnostic category.

### Hypotheses

At the outset of the Kollegievejens School study the following hypotheses were formulated:

#### Hypothesis 1

With the use of FM technology, attention and concentration improves so that the child with autism spectrum disorder is better able to function in social interaction situations.

#### Hypothesis 2

With the use of FM by the child with autism spectrum disorder in social interaction situations, eye contact in relation to communication will be more appropriate. The child's ability to follow a conversation will improve.

#### Hypothesis 3

With the use of FM by the child with autism spectrum disorder, active participation

in communication will improve.

#### **Hypothesis 4**

With the use of FM by the child with autism spectrum disorder, motor restlessness will be reduced.

These hypotheses were formulated based on observations during an earlier pilot project in which Phonak EduLink was used by children with autism spectrum disorder. There are only two older published studies on FM systems for children with ASD (Smith et al., 1981, and Smith et al., 1985), and the equipment used in these studies was large, bulky, and antiquated. Despite the use of older equipment however, the results of these studies were highly positive. When using FM systems, children with ASD significantly improved their attention, which was accompanied by more appropriate behavior and reduced sensory arousal.

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#### **Test subjects, study design, FM devices, outcome measures**

The investigated group consisted of pupils attending Kollegievejens School. The criteria for inclusion in the study were that the pupils had a language development level comparable to at least two years of age and pupils that were between 6 and 16 years old. 25 pupils who fulfilled these requirements were selected (3 girls and 22 boys). All subjects were diagnosed with ASD in accordance with the diagnostic criterion ICD-10.

An AB-intervention-withdrawal experimental design was used in order to identify any effects that FM use has on the pupils with ASD, when they participate in social interaction situations. To examine this, the study was divided into two types of sessions:

A: Pupils tested without using FM

B: Pupils tested using FM

All sessions were videotaped for future analysis by observers. The independent cause variable was the use of FM. The dependent effect variables were the outcomes of the analyses of the different observations in social interaction situations, registered and analyzed via the video recordings. To minimize the effects of possible other variables, the following precautions were taken:

- Both sessions took place in identical situations; in the same room and at the same time of the day.
- Both sessions used the same test materials.
- The pupils were situated in the same place in the room each time.
- The same test instructor was present at each test session.

A laboratory environment was constructed in order to control the physical conditions. The pupils were therefore removed from their usual physical surroundings. Sessions took place in rooms where stimuli such as light, sound, and objects from the school environment were controllable, so that pupils were not distracted during the testing sessions.

The group functioned as its own control group so that all pupils had an equal amount of sessions with, and without, FM. This allowed for an evaluation of the effect FM use has on the individual child. Allowing each pupil to serve as its own control eliminated any variability between pupils from the results.

In the test room containing two video cameras, a table and 5 chairs were arranged. Each camera taped two pupils at a time. Each camera was operated by one person. These camera operators did not participate actively in the testing sessions.

The FM system consisted of a wireless microphone-transmitter combination (Phonak Campus) and one or more open-fit ear-level receivers (Phonak EduLink), all operating on the same FM channel. The microphone picks up speech signals and the transmitter sends them to the EduLink FM receivers. The FM receiver has a totally 'open' fit, which enables the pupil to still hear sounds from their surrounding environment, such as noise from class mates, background sounds and the pupil's own voice.

Pupils were tested in social interaction situations in 2 sessions: one session without FM and one session with FM. Each semi-structured session comprised three different tasks, each 20 minutes in length, where 3 to 4 pupils worked with a test leader who functioned as chairman. The subjects were divided into 7 groups. The constellation of the groups was determined by age, class, and developmental level.

The sessions included questions about newspaper pictures, a quiz, and a final task which consisted of reading a story out loud, plus follow-up questions related to the story. The material was the same level of difficulty for each session. The newspaper pictures were identical for each pupil and there were new pictures for each session. The quiz and reading were specifically chosen in relation to the group's developmental level.

The resulting films of the sessions were recorded and registered by three observers. These observers used rating scales developed specifically for the study (see the scales below).

The three observers were not the same each time. All in all 15 observers took part. Instruction of the observers was organized and conducted by an appointed observation leader. Videotaping included parts of newspaper task, quiz, and reading task.

To document the effect of FM use a new instrument was developed to compensate for the lack of formal tests in this field. This development was carried out based on observations made in a previously conducted pilot project.

Four areas of observation were chosen; attention and concentration, language and communication, eye contact, and body language. These areas were rated according to the following scale, where 0 is consistent with the pupil's starting point without FM:

-2 = marked negative change

-1 = some negative change

0 = no change

+1 = some improvement

+2 = marked improvement

In parallel to the systematic analysis of the pupils' behavior in structured and controlled situations, subjective observations by parents were also collected, describing their children's behavior when using an FM system in situations outside the school environment.

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#### **Results**

For each of the four areas of observation (attention and concentration, language and communication, eye contact,

and body language), the ratings were calculated and the condition using FM was compared to the condition with no FM. The following details the improvement with FM:

### 1. Attention and Concentration

Overall a clear improvement in attention was seen (see Figure 1).

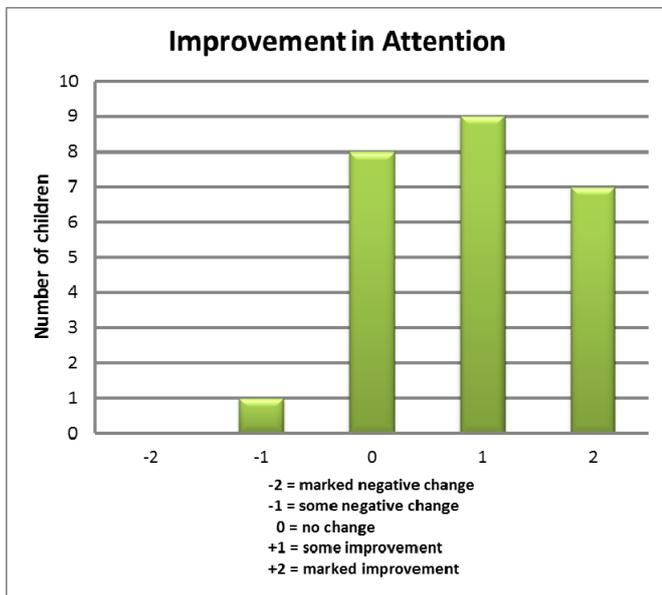


Figure 1. 9 out of 25 children with ASD showed some improvement in communication and 7 children showed a marked improvement, while 8 children showed no difference and one child showed some negative change in communication.

Overall a clear improvement in concentration was also seen (see Figure 2).

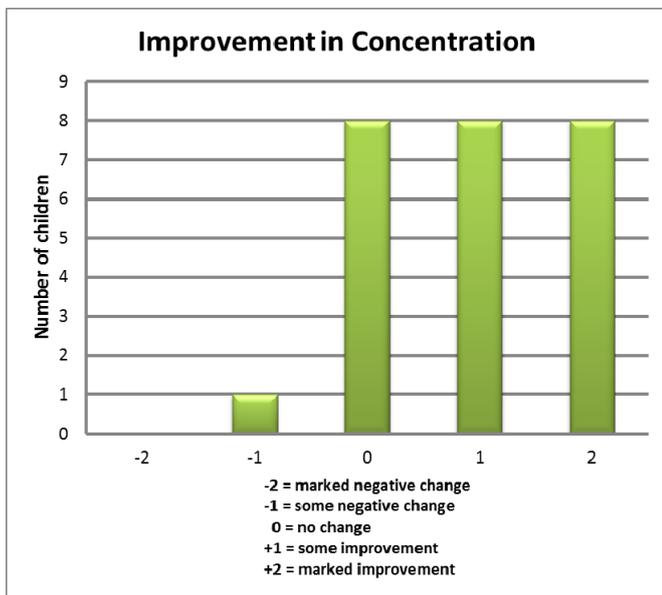


Figure 2. 8 out of 25 children with ASD showed some improvement in communication and 8 children showed a marked improvement, while 8 children showed no difference and one child showed some negative change in communication.

### 2. Language scores

For the language and communication scores the observers had to rate various questions.

**Spontaneous Communication:** Does the pupil communicate spontaneously? Does the pupil make spontaneous remarks? The results were that 10 pupils (40 %) showed some improvement with FM and of these 10 pupils 8 (33 %) showed a marked improvement of spontaneous communication when they used FM, e.g. they asked questions and made remarks without being encouraged.

**Mutual Conversation:** Is the pupil able to remain in a dialogue? Does the pupil try to rephrase themselves if a remark is not understood? Can the pupil talk about a subject suggested by someone else?

The results were that 12 pupils (48 %) showed some improvement with FM. These pupils were capable of maintaining a dialogue with the test leader or other pupils.

### 3. Eye contact

**Irrelevant focusing:** Does the pupil avoid focusing on the person talking? Does the pupil focus on other things, other than what he/she is supposed to? For example, the pupil looks out the window or directs their attention towards objects in the room.

The results were that 16 pupils (64 %) showed some improvement with FM. Of these 16, 13 pupils (52%) showed a marked improvement with regard to eye contact.

**Direction of a dialogue:** Is the pupil able to understand the direction of a dialogue? Is the pupil capable of waiting his/her turn? Is the pupil able to follow a dialogue and at the same time look at the person talking to them?

The results are shown in Figure 3. Although one child showed a marked negative change, 19 out of 25 pupils improved their scores, and of these 13 pupils showed a marked improvement.

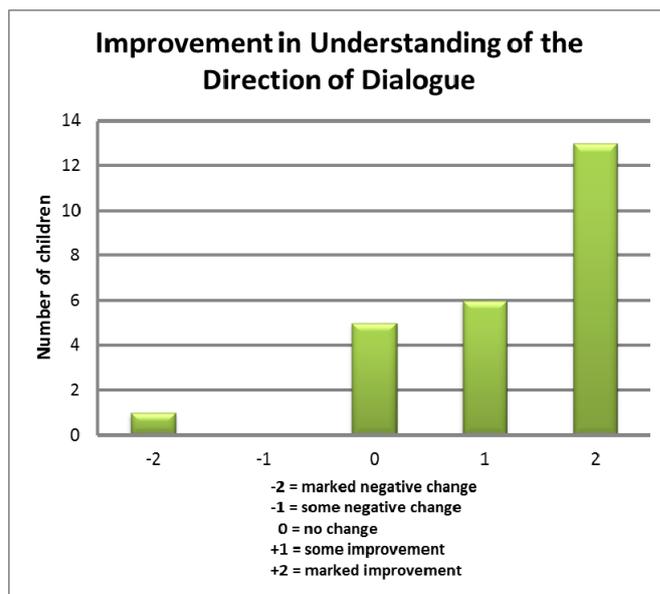


Figure 3. When the pupils use FM, 19 out of 25 (76 %) improve their scores, i.e. they improve in their ability to turn their eyes towards other pupils or staff members; they improve their ability to direct eye contact from one person to another and follow a conversation with their eyes.

#### 4. Body language

**Stereotype behavior:** Does the pupil display repetitive movements and sounds? Does the child have stereotypical language?

15 pupils (60 %) showed a marked improvement with the use of FM. All pupils, except one, displayed a reduction in self-stimulation. Their movements were calmer, and they were better able to direct their attention towards the test leader.

**Activity level:** for this part of the testing the 25 pupils were divided into two groups. One group featured 12 pupils and the other group the remaining 13. The first group included pupils with ASD whom at the beginning had a high level of activity. The other group comprised pupils with ASD whom at the beginning had a low level of activity.

A) High activity level group: the typical child in this group without FM is physically restless, constantly moving, unable to sit in the chair, have difficulties waiting their turn, and has the tendency to interrupt others.

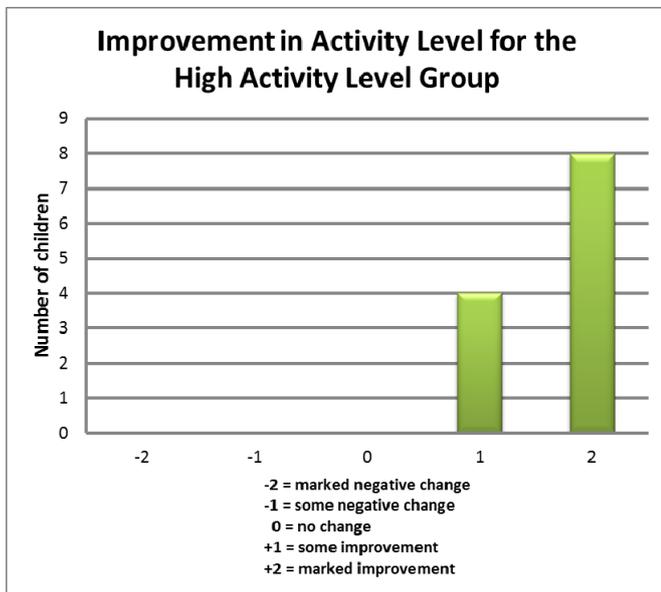


Figure 4. Of the group of high activity pupils all 12 pupils (100 %) show an improvement with FM, 4 show some improvement and 8 a marked improvement. Generally, social interaction is calmer, and the pupils are better able to interact in a more appropriate manner.

With FM, their level of activity approached a more appropriate level (see Figure 4).

B) Low activity level group: the typical pupil in this group without the use of FM is more passive. The pupil shows with their body language that they are not interested in participating in activities. e.g. by lying across the table.

With FM, 9 out of 13 pupils (69 %) showed an improvement (see Figure 5). They participated more actively with their bodies and participated more actively in conversation. The pupils who previously were more passive became more active.

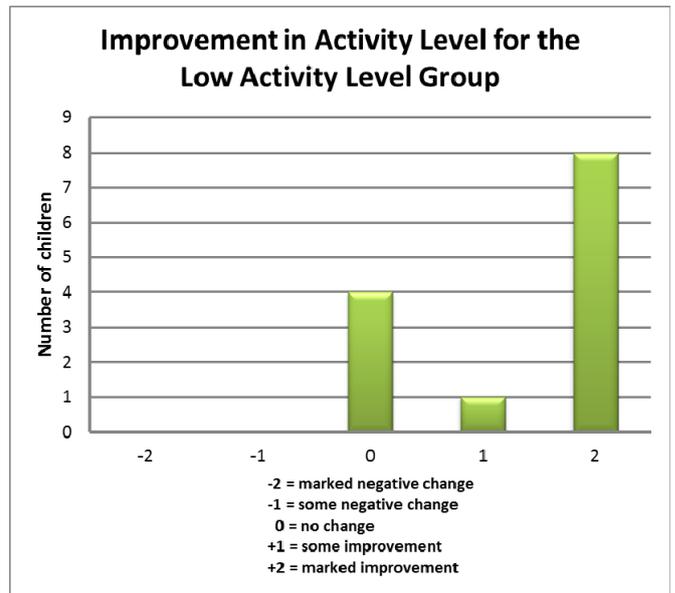


Figure 5. 9 out of 13 pupils (69 %) show an improvement with FM. They participated more actively with their bodies and participated more actively in conversation. The pupils who previously were more passive became more active.

In Table 1 a summary of all results is shown.

	Focus area	Worsened	Unchanged	Improved
	ATTENTION AND CONCENTRATION	%	%	%
1	Attention	4	32	64
2	Concentration	4	32	64
	LANGUAGE			
3	Spontaneous Communication	0	60	40
4	Reciprocal Conversation	0	52	48
	EYE CONTACT			
5	Irrelevant focusing	8	28	64
6	Direction of Dialogue	4	20	76
	BODY			
7	Stereotype behavior	4	36	60
8	High Activity Level	0	0	100
9	Low Activity Level	0	31	69

Table 1. The four main areas and 9 subcategories investigated in this study, showing the percentages of children with autism spectrum disorder who showed a worsening, no change or improvement as a result of FM system use.

## Conclusions and discussion

### A) Formal research

With regards to Hypothesis 1 it can be stated that with the use of FM an improvement of attention and concentration occurs, enabling the child with autism spectrum disorder to develop and maintain their skills in relation to social interaction situations.

This hypothesis is confirmed by the fact that the attention of 64 % of the pupils improved with the use of FM, and 64 % obtained an improved level of concentration when using FM. During the study, it was observed that the pupil's auditory

impression improved, when they directed their attention towards the person they were talking to. Likewise, the pupils were capable of directing their focus between several people, allowing them to follow the direction of a dialogue and maintain their concentration in social interaction situations.

With regards to Hypothesis 2 it can be stated that with the use of FM in social interaction situations, eye contact was more appropriate, and the pupil's ability to follow the direction of a dialogue also improved.

This hypothesis is confirmed by the fact that 64 % of the pupils reduced their focus on irrelevant stimuli and 76 % gained strength in relation to following the direction of a dialogue.

The pupils who earlier failed to maintain eye contact, mastered direct eye contact with the people talking to them. With the use of FM, the pupils were able to follow a conversation between the people talking in social interaction situations. Thus, the pupils showed an ability to follow the direction of a dialogue.

With regards to hypothesis 3 it can be stated that with the use of FM, an improvement of active participation in communication was apparent. 40 % of the pupils showed improvements in spontaneous communication, and 48 % showed improvements in mutual conversation.

With regards to hypothesis 4 it can be stated that with the use of FM, a reduction of motor restlessness is achieved. 60 % of the pupils reduced their stereotyped behavior when they used FM. 100 % of the pupils with high activity levels reduced their hyperactivity, and 69 % of the pupils with low activity levels became more active in social interaction situations. In general the pupils' activity levels in social interaction situations improved.

The study focused on the areas concerning social interaction situations. When the FM was not used the situation was characterized by distracting noise, restlessness, a lack of attention and concentration, and pupils having difficulty maintaining attention and participating actively in the chosen assignments. These situations also showed a distinct tendency for the pupils to be negatively affected by each other. The results have shown that pupils using FM improved their social skills. There was an increase of attention and concentration, better understanding of the aspects of a dialogue, a decrease of self-stimulation and hyperactivity, and an increase in activity levels for pupils with low arousal. In short, many of the pupils succeed in participating in the designed social interaction situations.

Attention interferes with many cognitive areas, where it can manifest as dysfunctional sensory integration. Appropriate sensory integration requires the ability to direct attention towards specific sensory inputs and ignore others. Sensory integration also requires that all the senses can be integrated into a whole, which can be achieved by stimulation of the auditory sense. When attention is stimulated, other cognitive functions are likewise stimulated and intensified. The test situation in this study is a common situation, whereby many things happen at the same time. In such situations, pupils had to be able to focus and steer their attention.

Pupils with ASD can have difficulties sorting out sensory inputs. If they are unable to perceive and sort out these , they will have difficulties distinguishing between what is essential and what is not.

When sensory integration is optimized and a pupil is able to integrate their senses in a global context, the pupil will show a better tolerance in relation to changes in the social and communicative environments. Thereby, the pupil's stress level will be minimized, which again increases their potential for learning and development. Consequently, it can be concluded that FM use has a positive effect on relational competences in pupils with a pervasive developmental disorder.

## **B) Subjective observations outside of the school environment**

FM systems were also used in unstructured situations outside school, for example grocery shopping. In these situations, positive observations were apparent. A place like a grocery store is filled with many distracting sensory inputs and many people. In these environments a pupil can become uncomfortable and anxious. In situations like this, a pupil with ASD will often display self-stimulatory behavior, such as the flapping of the arms, jumping up and down, or making repetitive loud noises. Some pupils refuse to enter such places and react by screaming, kicking, or demonstrating other types of problematic behavior in order to avoid the situation.

When pupils used FM systems in the grocery store, their contact with adults became more normalized. They were able to maintain contact and walk next to the adult, rather than 2-3 meters in front of them.

A parent of one of the pupils, who earlier refused to go into the grocery store, commented that after using the FM system the child now enjoys going grocery shopping. If the pupil notices a grocery bag when the parent comes home, he will typically ask: "Did you go grocery shopping without me?"

The FM gave the pupils the possibility of following an instruction and singlehandedly going to fetch a product. Pupils who previously were too anxious to leave the teacher or parent gained confidence through the use of the FM and became more curious and interested to explore different physical settings.

In other situations outside school, e.g. horseback riding, where there are many different smells, sounds, strangers and large animals, pupils had to be able to follow a precise instruction, often given from a distance. Children with a high degree of stereotypical behavior combined with difficulties in listening and reacting to verbal commands, were better able to follow the instructions of the riding instructor when using FM.

In situations such as swimming or exercising where the pupils had to attend to many tasks and distracting stimuli, the FM was also proven to help. The pupil had to perform a variety of complex tasks, such as undressing, putting on gym clothes, and organizing the clothes that he/she just took off.; tasks can easily get confusing for pupils. However when pupils used FM it provided them with a more optimized perception, so that they were more able to follow instructions. This also meant that the pupils needed less time to complete the tasks at hand when they used the FM system.

Through the use of FM, children with a pervasive developmental disorder improved with regards to maintaining concentration and paying attention to receiving instructions and support from a staff member or parent. Through auditory contact with an adult, pupils that show self-injuring behavior and anxious pupils were better able to participate in anxiety provoking situations, such as performing with a band in front of a large audience or playing on the playground with many other pupils.

Pupils experienced an increased ability to master the above-mentioned situations and this resulted in their success and increased self-confidence. Moreover, pupils experienced those social interaction situations with the staff member as much more pleasant.

### C) Parents' Comments about FM

Parents who used the FM system at home had many successful anecdotes to tell, for instance regarding their child's changed behavior during meal times. Eating situations include a lot of noise, from plates, cutlery etc., and talk from the people around the table. In this situation, it is difficult to sort out what is relevant sound and what is irrelevant. This means everything is perceived as chaotic sensory input. In these situations, the child feels uncomfortable and anxious, resulting in problems remaining at the table. They quickly become uneasy and leave.

Other parents who used the FM reported positive experiences when reading stories. In these situations children were better able to concentrate for longer periods of time. Furthermore, children made comments on the story, which they never did before.

Some parents mentioned that when their child was using FM they were better able to respond properly to questions the parents asked, and the answers came faster than before. At the same time, children better understood when it is right to talk and when it is right to keep quiet.

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### Caveat

Finally, we must emphasize that the positive results of this research project should not in any respect be seen as a cure for autism. What this research project has documented is that Kollegievejens School has developed an effective aid and method, which has demonstrated a positive effect in social interaction situations that pupils previously found highly problematic.

Kollegievejens School still believes that structured teaching and predictability is the foundation for the educational program for pupils with autism spectrum disorder. In this respect, the use of an FM system can help professional staff and parents create an enriching environment for learning and development in everyday life for pupils with ASD.

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### Outlook

This article has examined auditory sensory reinforcement by means of the Phonak EduLink FM system in relation to sensory integration. An interesting direction would be to examine whether auditory sensory integration might also help children with ASD to cope with other hurdles and problems. For example, can FM be of use as a tool for

increasing an individual pupil's inclusion in a normal school setting?

As the results of this study have not been published in a peer-reviewed scientific magazine, Phonak has initiated several more studies by leading experts into the benefits of Phonak's Dynamic FM systems for children with Autism Spectrum Disorder. These studies are underway at present (February 2011).

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### Acknowledgement

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